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Final Report for the LARS/Purdue - IBM Houston Scientific Center Joint Study Program

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The Laboratory for Applications of Remote Sensing

Purdue University
Lafayette, Indiana

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I. Summary

This report describes work performed during the second part of the LARS/IBM HSC Joint Study program which began April 1, 1971 and terminated April 1, 1972. Work during the first part of the study ending November 30, 1971 concentrated on analysis of the HSC vidicon film scanning system. Included was a comparison of data derived from this system and the LARS/U. of Michigan airborne multispectral scanner system. Comparison of vidicon digitized film and film digitized on a rotating drum microdensitometer was also included. This work is reported in IBM Publication No. 320.2421 "First Interim Progress Report for IBM Houston Scientific Center/ LARS - Purdue Joint Study Program." The second part of the study consisted of development of a closed boundary finding algorithm by IBM and its evaluation by LARS. The purpose of the algorithm is to enable automatic determination of boundaries, such as agricultural

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field boundaries, in digitized aerial or satellite imagery. The algorithm is described and a pictorial evaluation is presented in this report.

II. Field Selection in Digital Images

One of the major problems in the development of automatic pattern recognition systems for earth resources image data is the delineation of closed boundaries around homogeneous areas containing a material of interest. Identification of these closed areas allows categorization of all the enclosed image elements by group pattern recognition techniques. The reliability and speed of the pattern recognition process is markedly increased when groups, i.e., fields, of samples are used. If the fields are not known each image element in the data must be classified separately which is very time consuming and less accurate. Thus, closed boundary finding methods are being widely studied as part of earth resources data analysis research.

Recent work reported by Rosenfield[1] and Anuta[2] approached the boundary finding problem using the picture gradient which spatially differentiates the data and produces an edge picture. The problem with this approach is that the gradient is inherently "noisy" and produces borders which are discontinuous, of varying width, and the output also consists of many isolated spurious border points. A more stable and lower noise approach using clustering is reported by Wacker.[3] The quality of his boundary output is high; however, the algorthm is very time consuming and closed boundaries are not guaranteed. The boundary finding algorthm reported here guarantees closure and is relatively fast. The algorithm description which follows is extracted from an IBM report by Rodd[4] who developed the program.

III Closed Boundary Finding Algorithm (CBA)

In the following discussion each point of a digital picture is called a pixel (picture element) and a group of points is called a pixel group. In the implementation, pixel groups are squares of g pixels on a side and thus have g^2 pixels in each group. A field is a collection of pixel groups which have been found to come from the same statistical distribution. The algorithm proceeds by computing statistics for a pixel group and comparing them to the statistics of existing sets of pixel groups using the t - test[5]. The t - test is used to determine whether two adjacent groups came from the same distribution and thus from the same field.

1. Statistical Method

Before describing the geometry of building fields using more than one spectral range we describe the statistical method used when comparing two samples. The t-test is used to compare a pixel group which has not been classified as part of a field with some other pixel group or set of pixel groups which form a defined field. The formulas used make two assumptions about the population formed by the pixels: (1) the populations of all fields are normal and (2) the populations of all fields have the same variance.

Call the unclassified pixel group sample 1 and the collection of one or more pixel groups which are classified sample 2. The goal is to compute a value of t to compare against a critical value to determine if the two samples are from a single population (i.e. determine if the pixel group is part of the same field as sample 2).

Let:

X_{ij} be pixel i of sample j,

$\bar{X}_j$ be the mean of sample j,

x_{ij} be $(X_{ij} - \bar{X}_j)$,

n_j be the number of pixels in sample j.

Note that $N_j = g^2$ if only one pixel group is considered.

First compute the pooled estimate of variance.

$$s_p^2 = \frac{\sum_i x_{il} + \sum_i x_{i2}}{(n_1-1) + (n_2-1)}$$

Note that the $\sum_i x_{ij}^2$ is computed as usual by

$$\sum_i x_{ij} = \frac{n_j \sum_i x_{ij} - (\sum_i x_{ij})^2}{n_j}$$

Now the value of t is:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{s_p^2 \left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

A two-tailed test is used with the number of degrees of freedom equal to $(n_1 - 1) + (n_2 - 1)$.

Occasionally a single pixel group will contain pixels from two areas with radically different values of $\bar{X}_j$ or will contain mostly pixels from say a darker area and one or more pixels from an extremely bright area such as a road or a house with a white roof. This will make s_p^2 very large and consequently make t very small thus confirming the null hypothesis that the two samples are

from the same field. Actually this is not the case for sample 1 does not belong with any other pixel groups. In fact, if sample 1 is included in the field with sample 2, any further computations of t using the field with samples 1 and 2 now combined into a single field will produce a large s_p^2 and small t and an acceptance of the null hypothesis. What has really happened is that sample 1 violates assumption 2. To avoid the problem it is necessary to compute the standard deviations σ_1 and σ_2 and if either is greater than some empirical constant times the appropriate $\bar{X}_j$, the null hypothesis is rejected.

2. Building of Fields

The picture is processed one row of pixel groups at a time. First the field building algorithm will be described in terms of processing a picture of one spectral band. Before processing starts on a row of pixel groups, the sums of the elements and sums of the squares of the elements of each pixel group in the row are computed. The pixel groups are numbered left to right so that s_1 is the sum of elements of the leftmost pixel group in the row and q_i is the sum of the squares of the elements of the leftmost pixel group. There are W pixel groups in a row.

The k'th group of the row of pixel groups being processed will be designated as group k. The first group in the current row is thus group 1. The field to which group k is assigned is given by f_k. The k'th pixel group in the previous row of pixel groups is designated as group (k). The first such group is group (1). The field to which group (k) is assigned is given by $(f)_k$.

The first row is easiest to process. Group 1 is arbitrarily assigned to field 1 and field 1 is noted as containing one pixel

group. Letting S_n be equal to the sum of the pixels in field n and Q_n be equal to the sum of squares of pixels in field n, then S_1 is equal to s_1 and Q_1 is equal to q_1.

Now group 2 is compared to group 1 (group 1 is sample 2 and group 2 is sample 1). If the null hypothesis is accepted, group 2 is added to field 1. Adding to field 1 means noting that field 1 now has 2 pixel groups and

$$S_1 = S_1 + s_2$$

$$Q_1 = Q_1 + q_2.$$

If the null hypothesis is rejected, then group 2 is assigned to field 2 and field 2 is noted as containing one pixel group and

$$S_2 = s_2$$

$$Q_2 = q_2.$$

Next group 3 is compared to group 2 and in general group k is compared to group k-1 until the end of the row is reached.

The second row and all succeeding rows are processed by the following steps.

(a) Group 1 is compared to the field containing group (1). Two possibilities exist. Either the null hypothesis is accepted and group 1 is considered part of field $(f)_1$ or the null hypothesis is rejected and group 1 is different.

If they are the same (i.e. group 1 is part of field $(f)_1$), group 1 is added to field $(f)_1$. Adding means noting that field $(f)_1$ has one more pixel group and

$$S(f)_1 = S(f)_1 + s_1$$

$$Q(f)_1 = Q(f)_1 + q_1.$$

Note that $S(f)_1$ means the $(f)_1$'th element of S where $(f)_1$ is the field to which group (1), the first group on the previous row, was assigned.

If they are different processing continues to group 2.

(b) Group 2 through W-1 are processed in the same manner. Group k is compared to the field which contantains group (k).

If they are the same, group k is added to field $(f)_k$. Then a check is made to see if group k-1 has been assigned to a field. If so processing continues to group k+1. If not, group k-1 is compared to field f_k (which is the same as $(f)_k$). If they are different, processing continues to group k+1. If they are the same, group k-1 is added to field f_k and then a check is made to see if group k-2 has been assigned to a field and so on.

If they (group k and field $(f)_k$) are different a check is made to see if group k-1 has been assigned to a field. If not, processing moves to group k+1. If so, group k is compared to field f_{k-1}. If they are the same group k is added to field f_{k-1}. If not, processing continues to group k+1.

(c) Group W is processed just like groups 2 through W-1 except that upon termination of processing of group W, there is no group k+1 to begin processing.

(d) After group W is processed, a second pass of the row is made, this one backwards across the row. The pass starts at group W. When a group k is encountered which has not been assigned to a field, group k is assigned to a new field. Then

if group k-1 is unassigned, it is compared to group k. If they are the same, group k-1 is added to field f_k and group k-2 is checked to see if it is unassigned and so forth. Whenever group k-j is unassigned but different from the field which contains groups k through k-j+1, then group k-j is assigned to a new field and a check is made to see if group k-j-1 is assigned and so forth. Whenever group k-j is already assigned, scanning continues for unassigned groups.

To handle multi-spectral data, a vector S, a vector Q, a vector s and a vector q must be maintained for each spectral band. When two samples are compared, a t is computed for each spectral band. If the null hypothesis is rejected on the basis of the value of t for any spectral band, then the samples are different.

IV. Implementation

The algorithm has been implemented on System/360 under CP-67/CMS. The program is written in FORTRAN with the exception of assembly language subroutines for input data conversion and for timing. The data for each channel are on a separate file on secondary storage. The data files are sequential with each record containing one row of pixels. It is simple to adapt to some other format of raw data because all input of pixel data is done from a single subroutine.

The following parameters are input to the program:

1. The value of g, the number of pixels on one side of a pixel group.

2. Those rows and columns of the picture which are to be processed.

3. The significance level to be used for the t-test. Four values are available.

4. The number of channels to be processed.

The program can process any number of rows of pixels on a single run. The number of columns is limited by the dimensions of certain variables. Thus, the program is designed to process pictures which are long strips.

Output is to a line printer. Results for the first 50 rows of pixel groups are printed after the first 100 rows are processed and results for the next 50 rows printed after another 50 rows have been processed and so forth. On the output, each field is assigned a character. Only the boundaries of each field are printed. The program is intended to be used with a per field classification program so that when a field is closed (closed means that no pixel groups in the current row of pixel groups belong to that field), the classification program is invoked to classify the closed field as corn etc. Also before printing, any fields in the last row to be printed which are still open need to be classified.

Note that the maximum number of fields which can be open at one time is twice the number of pixel groups in a row. Thus the vectors S and Q need have only 2W elements since each time a field is closed, those elements of S and Q which contained the information concerning the field just closed can be relaeased for use by a new field.

A source listing for the program modified to work on the IBM System 360 44PS operating system is included in Appendix I. A discussion of the input data and the program is supplied in Appendix II.

V. Evaluation of the CBA

In order to analyze the performance of the closed boundary finding algorithm the program was applied to two remote sensor data sets. The primary application was to aircraft multispectral scanner data from flights over agricultural areas in Indiana. Regions such as this contain a uniform checkerboard pattern of rectangular fields oriented generally in a north-south direction. Imagery gathered over this area using north-south flight paths will contain a field boundary structure which is colinear with the X-Y axes of the imagery. These conditions make data of this type ideal for testing boundary finding algorithms due to the predictability of the scene border structure. A 1 mile by 8 mile strip of this agricultural scanner data was used to test the CBA using a variety of parameter values for the algorithm.

The CBA was also applied to a second data set to observe the behavior of the algorithm on irregular and randomly shaped features in the imagery. The data set is from a flight over Yellowstone National Park, Wyoming, and contains meadow, forest, rock outcrops and other irregular features.

These test cases are presented as examples to show the typical performance to be expected from the algorithm for these image context categories. The evaluation method is strictly subjective since no reference standard or qualitative evaluation method exists for testing

the boundary results. Field by field visual analysis enables a reasonable judgement to be made as to the quality and consistency of the closed fields the algorithm is finding. Thus, gray scale pictorial printouts and the corresponding closed boundary finding algorithm printouts having the same scale are presented in figure form for documentation and evaluation purposes in this report.

A typical CBA result is presented in Figure 1. A gray scale pictorial computer printout is presented in Figure 1a for a strip of data in the .58 - .65 micrometer band of typical Indiana farm land. This image was generated using a set of 10 print chain characters which reproduce an approximation of a gray scale. The CBA output in Figure 1b was generated using the following parameter values: Minimum points per field = 128; Significance level = 4; Channels = 4,6,8; Pixel group size = 2 by 2. It is difficult to visually evaluate the results on a large scale. Individual fields must be selected in the gray scale printout and the corresponding area located in the CBA output. Inspection of many fields in this manner reveals that the basic border structure of the scene is being captured and in general each field in the gray scale tends to be broken up into two or more subfields. A fixed sequence of symbols is used to represent the closed boundaries and the sequence is repeated as the set of available symbols is exhausted. It is assumed to be desireable to have too many fields defined rather than too few since then there will be less chance of a CBA field covering more than one real field. Also it is entirely reasonable to expect that real fields will contain variabilities which translate to separate sub-fields when observed spectrally.

In order to evaluate the sensitivity of the CBA to variations in the program parameters several figures were generated from CBA output for visual comparison. The minimum number of points allowable for a field is moderately influencial in determining the nature of the border output. In Figure 2 three values for MINFLD are illustrated. The difference between MINFLD of 32 and 64 is not great; however, sharper and more linear borders are obtained for MINFLD = 128. The minimum field of 128 picture elements corresponds to 2.4 acres for the scale of this data. Larger minimums may be desireable if the average size of the sub-fields in the scene is larger than this figure. Next, the significance level was varied and Figure 3 contains output for SIGLEV of 2,3 and 4. It is apparent that this parameter has the strongest effect on the CBA output. For values of 2 and 3 a great deal of border structure is lost and it is assumed that for this scene and three channel operation significance level 4 is the more desirable value to use.

The CBA was originally written to use one channel only to derive borders. The program was expanded to utilize multiple channels and the three channels used (4, 6, 8) tended to give the best results. These channels cover the .52 - .57 (green), .58 - .65 (red) and .72 - .92 (infrared) portions of the spectrum, respectively. These channels tend to be less cross correlated than other combinations of three thus contain more picture information than would channels demonstrating more correlation. Use of more than three channels tended to produce an excess of borders and the output was judged to be degraded. The comparison presented in Figure 4 is for a one-channel versus a three-channel run. It is apparent that a certain amount

of the horizontal border is lost while the vertical border structure appears to be captured relatively well.

These results tended to indicate that it is desireable to use multiple channels for border finding. This approach requires additional computation and the problem of selecting which channels to use is compounded. These considerations led to the decision to test the usefullness of the principal components transformations [6] in the border finding process. This transformation is linear and its effect is to concentrate the variance in the multiple image set in a minimum number of channels. The first principal component is an image channel formed as a linear combination of all original channels such that in this case approximately 75% of the variance in the image set is contained in it. The second principal component contains 12% of the variance, the third 7% and the rest the remaining variance on a decreasing scale. The possible advantages to using the principal components are that fewer channels may suffice and it eliminates the uncertainty of which channels to use.

The principal component transform was performed on the data set which was used to produce the previous output. The CBA was run on the transformed data using the first principal component in one case and the first three in a second case. The results of the runs are displayed in Figure 5 along with the three channel results from Figure 1. Again it is evident that the single channel result tends to miss horizontal boundaries as was observed for the single channel unaltered data. The three component results tend to agree with the

reference case. From this it was concluded that the principal component approach would simplify channel selection but more than one channel would still be required for processing.

The CBA was applied to one other data set obtained from an aircraft scanner flight over Yellowstone National Park, Wyoming, in 1967. A gray scale printout of the .52 - .55 micrometer band of the scanner data is presented in Figure 6. The same parameter values used for previous runs were used for the CBA and the output is pictured on the right in Figure 6. The elongated areas of meadow and rocky material are bordered reasonably well in the center and lower part of the area. The upper area contains forest stands and it is extremely difficult to evaluate what the CBA is doing here. Detailed evaluation of the performance for this scene is beyond the scope of this report and this evidence is presented as an example only.

VI Summary

A closed boundary finding algorithm is described which attempts to extract border information from digitized multispectral imagery. The algorithm was applied to multispectral aircraft scanner data from agricultural and wildland scenes to evaluate its performance. Visual evaluation of results indicate reasonably good performance in the agricultural scene; however, precise evaluation was not possible within the scope of this study. Subjective evaluation of performance for the wildlands case was more difficult than for the agricultural case.

Further work is needed to evaluate and optimize the algorithm. Once satisfactory performance is achieved the output of the CBA must be transferred to a field classification algorithm to achieve the initial intended purpose of the CBA. Classification of the fields could be performed as soon as the fields are closed (completed) or a field output definition could be made and classification performed later. One way this could be accomplished is for the CBA to write a border tape with the fields written in a format easily readable by a per field classifier program.

The processing rate for the present program on an IBM System 360 Model 67 is approximately .25 sec of CPU time per image line of 222 samples for 1 channel processing and .44 sec per line for three channel processing. The flightlines illustrated averaged 770 lines thus the three channel CBA processing time averaged 339 seconds CPU time. Processing time is not of major concern at this stage since quantitative evaluation of the algorithm is not yet achieved.

The close cooperation of the IBM Houston Scientific Center and the LARS Purdue organizations was instrumental in achieving the results obtained from this joint study. It is hoped that this document will serve as stimulus to further work on the problems discussed in this report and in the interim report.

References

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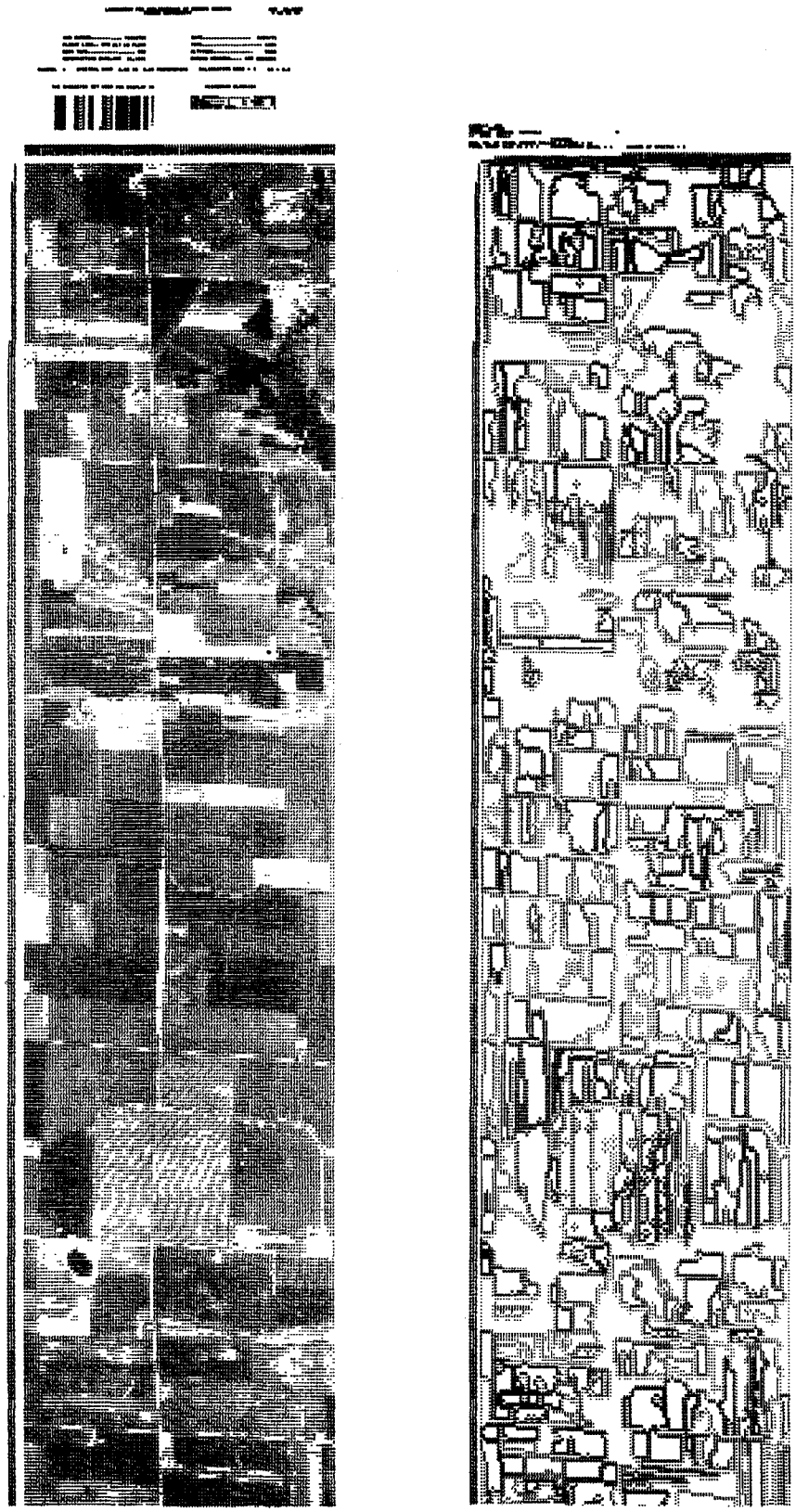
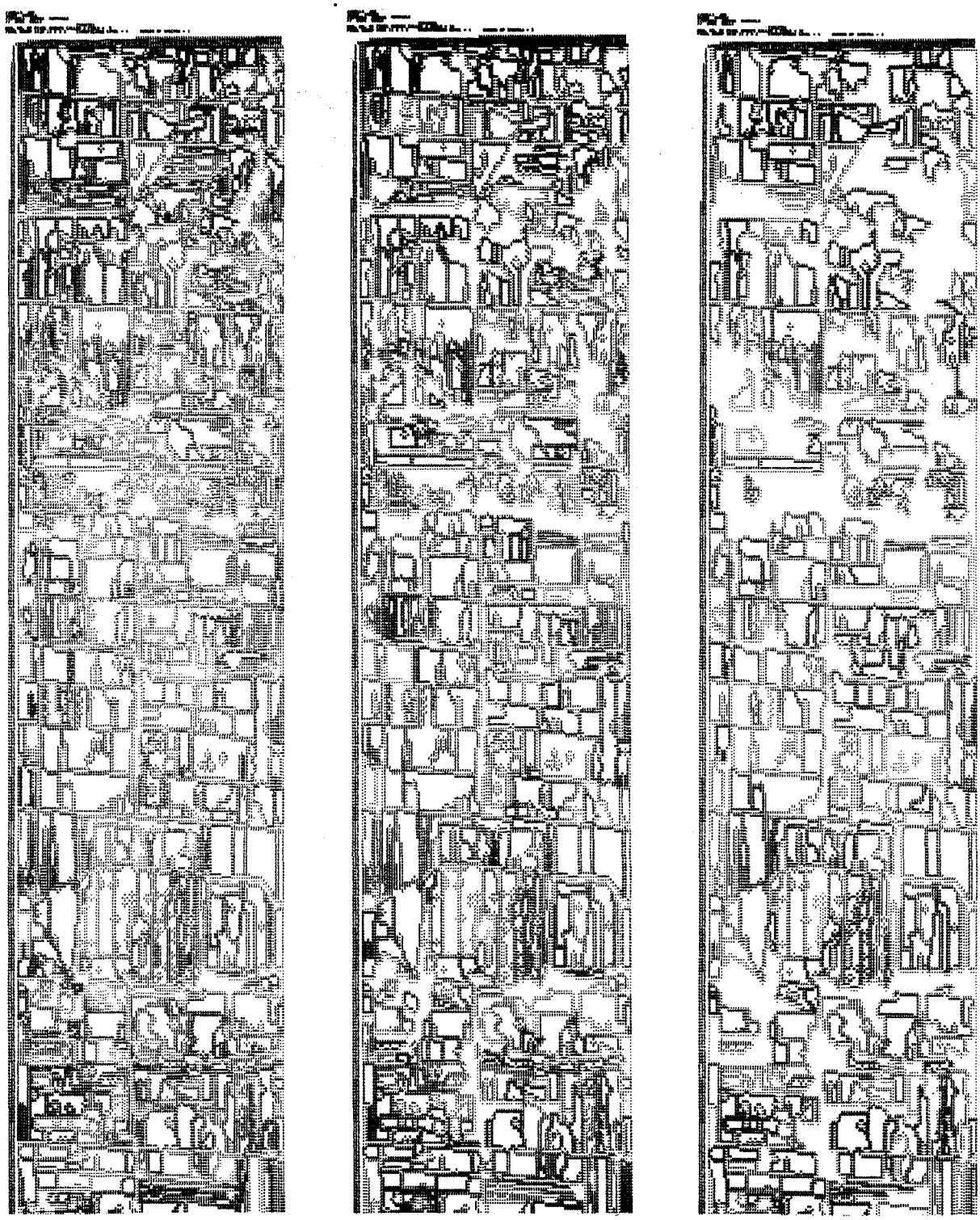


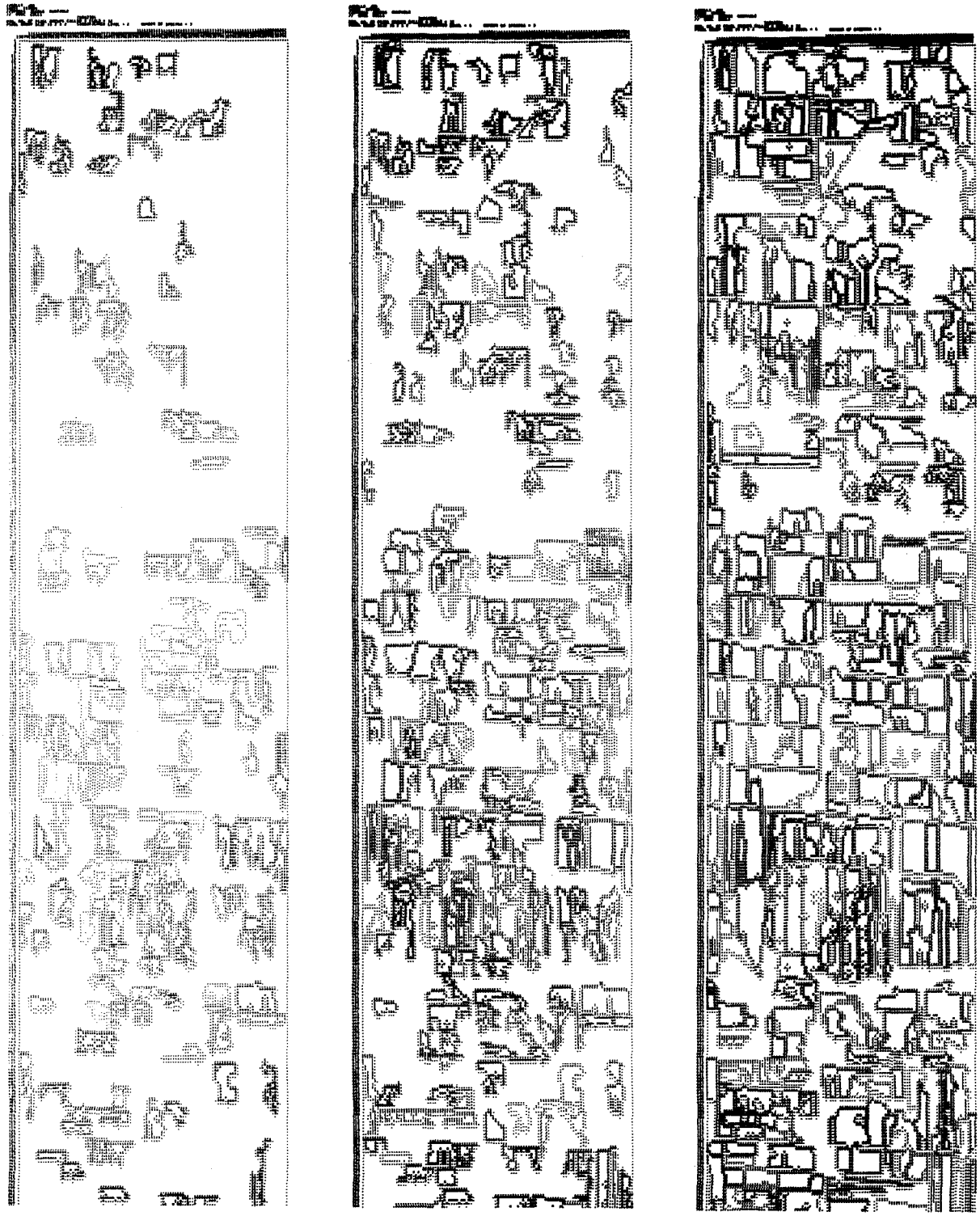
a) Gray Scale Printout b) CBA Output

Figure 1. (a) Gray scale line printer image of .58 - .65 micrometer band aircraft scanner data. (b) Closed boundary algorithm output for the scanner data. Parameters: MINFLD = 128, SIGLEV = 4, CHANNELS 4, 6, 8. LARS Run No. 71062701.



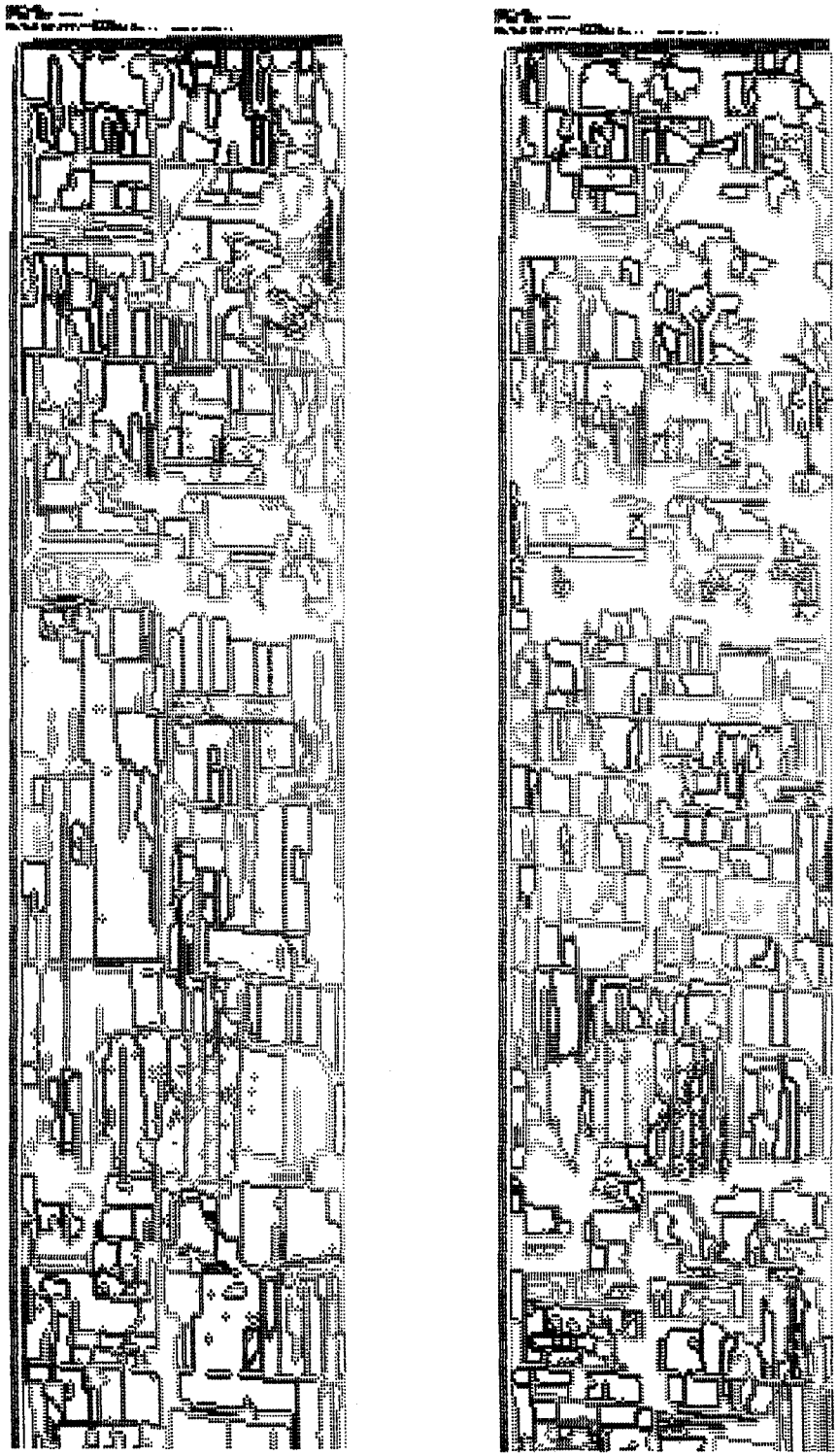
MINFLD = 32 MINFLD = 64 MINFLD = 128

Figure 2. Comparison of the effect of three values of minimum field size on CBA output. Significance Level = 4, Channels 4, 6, 8.



SIGLEV = 2 SIGLEV = 3 SIGLEV = 4

Figure 3. Comparison of CBA output for three values of significance level. Channels 4, 6, 8 and MINFLD = 128.



Channel 6 Channels 4,6,8

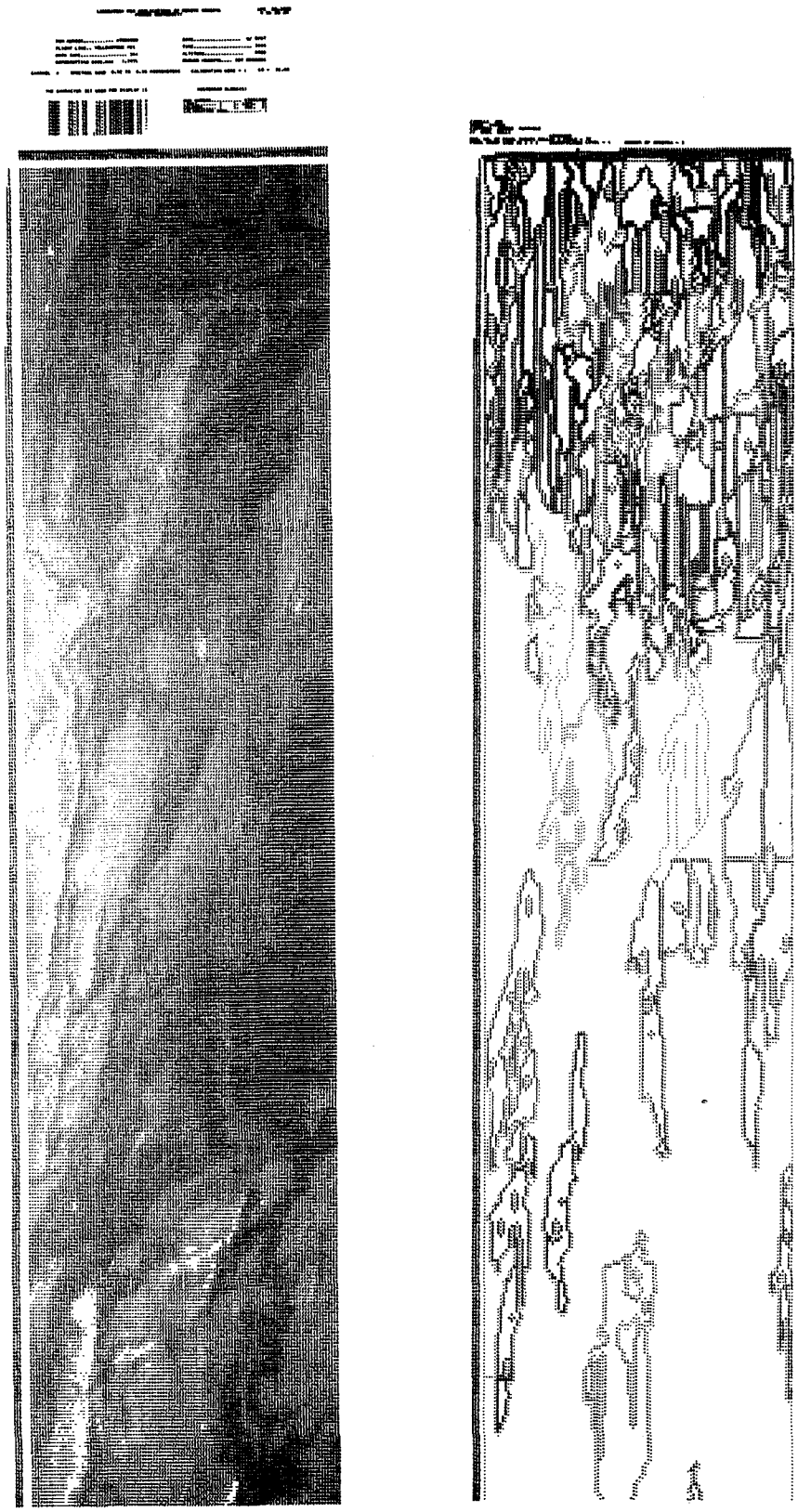
Figure 4. Comparison of CBA output for two sets of channels. Significance level 4 and MINFLD = 128 used.

3 Channels Untransformed

Principal Component 1

Principal Components 1,2,3

Figure 5. Comparison of CBA output from unaltered data and principal components data. MINFLD = 128, Significance Level 4.



Gray Scale Printout CBA Output

Figure 6. Gray scale printout and CBA output for forest and meadow topography in Yellowstone Park, Wyoming. Parameters: MINFLD = 128, Channels 4, 6, 8; SIGLEV = 4.

Appendix I

Fortran Listing of Closed Boundary Finding Algorithm

```
FORTRAN IV    MODEL 44  PS       VERSION 3,  LEVEL 4   DATE  72215

              C     MAIN ROUTINE FOR FIELD SELECTION PROGRAM.                          CEL00010
              C     MAIN CONTROLS THE  GEUMETRY OF FIELD BUILDING.                     CEL00020
0001                IMPLICIT  INTEGER*2  (E-Z)                                       CEL00030
0002                INTEGER** QUT, INT, JNR, 4S                                      CEL00040
0003                LOGICAL*1  SAME, ASIN, ENOUGH, CLOSE, OPEN                       CEL00050
0004                COMMON  AFTOT(250,4), AFS(250,4), ASUM(250,4), ASQ(256,4), AT(4),CEL00060
                   1     AFLD(2501, APGR), AST, APWR, OUT, IN, JNR, NS               CEL00070
0005                COMMON /INT2/ PIXI(1280), RWFLD(1256), OLDRW(256), STACK(250),   CEL00080
                   1     FSR(250), LASTAT(130)  SPI(130,100), PXGR, PXGR1, NCHAN ,  CEL00090
                   2     ROWS, W1, W2, WL2, WIDE, NFS, JW, JS, JR, KL1, IFLD, SIGLEV,CEL00100
                   3     IDF, 81, 82, IR1, IR2, ICLOSE, PCLASS, PWIDE, NEXT, JLINE  CEL00110
0006                COMMON /RESULT/ SAME, ASIN(256), ENOUGH(250), CLOSE(250),OPEN(250)CEL00120
0007                INTEGER*4   ITIMEN                                               CEL00130
0008                INTEGER*4 ID, RUNNUM                                             CEL00140
0009                COMMON /LABS/ ID(200), RUNNUM, RCSEL(30),                        CEL00150
                   1     COV(256,6), AFCOV(250,6)                                    CEL00160
0010                EXTERNAL ITIMER                                                  CEL00170
0011                J = ITIMER(I)                                                    CEL00180
              C     THE CALL TO ITIMER SETS  THE CLOCK.                              CEL00190
0012                CALL GETPRM                                                      CEL00200
0013                IFLD = 1                                                         CEL00210
0014                DO 37 I = 1,250                                                  CEL00220
0015                DO 30 J = 1,4                                                    CEL00230
0016                AFTOT(I,J) = 0.0                                                 CEL00240
0017             30 AFS(I,J) = 0.0                                                   CEL00250
0018                DO 33 J = 1,6                                                    CEL00260
0019             33 AFCOV(I,J) = 0.0                                                 CEL00270
0020                OPEN(I) = .FALSE.                                                CEL00280
0021                CLOSE(I) = .TRUE.                                                CEL00290
0022             37 AFLD(I) = 0.0                                                    CEL00300
0023                OLDRW(1) = 1                                                     CEL00310
0024                RWFLD(1) = 1                                                     CEL00320
0025                FSR(1) = 1                                                       CEL00330
0026                JR = R1+PXGR                                                     CEL00340
              C                                                                      CEL00350
              C     THIS CALL READS OVER ROWS OF THE PICTURE PRECEEDING THE FIRST ROW CEL00360
              C     TO BE ANALYZED.                                                  CEL00370
0027                CALL RDOVER                                                      CEL00380
              C                                                                      CEL00390
0028             39 WL2 = W2-PXGR1                                                   CEL00400
0029                CALL PRINTO                                                      CEL00410
              CV    INITIALIZATION IS NOW COMPLETE.                                  CEL00420
              C                                                                      CEL00430
              C     STARTING ON FIRST ROW.                                           CEL00440
0030                CALL PGROW                                                       CEL00450
              C     DO FIRST ROW OF PIXEL GROUPS.                                    CEL00460
              C                                                                      CEL00470
0031                WL3 = WL2-PXGR                                                   CEL00480
0032                JW = W1                                                          CEL00490
              C     SUBROUTINE SET ASSUMES THAT THE COLUMN OF THE NEW FIELD IS IN    CEL00500
              C     JW.                                                              CEL00510
0033                CALL SET                                                         CEL00520
0034                OLDRW(W1) = 1                                                    CEL00530
0035                DO 100 JW = W1,WL3,PXGR                                          CEL00540
0036                JS = JW+PXGR                                                     CEL00550
0037                CALL STU                                                         CEL00560
              C     CALL TO STU HERE ACTUALLY COMPARES TO A GROUP BESIDE.  THIS      CEL00570
              C     OCCURRS BECAUSE IN THE FIRST ROW OLDRW IS USED TO STORE THE      CEL00580
              C     CURRENT ROW.                                                     CEL00590
0038                IF (SAME) GO TO 45                                               CEL00600
              C     PIXEL GROUP TO RIGHT IS DIFFERENT SO START A NEW FIELD.          CEL00610
0039                IFLD = IFLD+1                                                    CEL00620
0040                NEXT = NEXT +1                                                   CEL00630
0041                FSR(IFLD) = 1                                                    CEL00640
0042             45 CALL ADD(IFLD,JS)                                                CEL00650
              C     ONE MORE PIXEL GROUP IN FIELD IFLD.                              CEL00660
0043                RWFLD(JS) = IFLD                                                 CEL00670
              C     BOTH RWFLD AND OLDRW ARE LOADED BECAUSE PKINT WILL USE RWFLD     CEL00680
              C     AND OLDRW IS NEEDED WHEN THE NEXT ROW IS STARTED.                CEL00690
0044            100 OLDRW(JS) = IFLD                                                 CEL00700
0045                CALL PRINT                                                       CEL00710
              C     PLACE RESULTS OF FIRST ROW IN PRINT ARRAY VIA CALL TO PRINT.     CEL00720
              C                                                                      CEL00730
0046                IR1 = R1+PXGR                                                    CEL00740
0047                IR2 = R2-PXGR1                                                   CEL00750
0048                JNR = 1                                                          CEL00760
              C     INITIALIZATION OF DO 250 LOOP WHICH WILL PROCESS ALL             CEL00770
              C     REMAINING ROWS.                                                  CEL00780
```

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FORTRAN IV    MODEL 44  PS       VERSION 3,  LEVEL 4   DATE  72215

0049                DO 250 JR = IR1,IR2,PXGR                                         CEL00790
0050                JNR = JNR +1                                                     CEL00800
0051                CALL PGROW                                                       CEL00810
              C     READ IN NEXT ROW OF PIXEL GROUPS.                                CEL00820
0052                DO 160 JW = W1,WL2,PXGR                                          CEL00830
0053                ASIN(JW) = .FALSE.                                               CEL00840
              C     INITIALIZATION OF PIXEL GROUPS AS ASSIGNED.                      CEL00850
0054                JS = JW                                                          CEL00860
0055                CALL STU                                                         CEL00870
              C     CHERC AGAINST GROUP ABOVE.                                       CEL00880
0056                IF (SAME) GO TO 130                                              CEL00890
              C                                                                      CEL00900
              C     PUT GROUP INTO SAME FIELD AS GROUP ABOVE.                        CEL00910
0057                NFLD = IFLD                                                      CEL00920
0058                NFLD = OLDRW(JW)                                                 CEL00930
0059                RWFLD(JW) = NFLD                                                 CEL00940
0060                CALL ADD(NFLD,JW)                                                CEL00950
0061                IF (JW .EQ. W1) GO TO 160                                        CEL00960
              C                                                                      CEL00970
              C     CHECK BACK ACROSS FOR UNASSIGNED GROUP.                          CEL00980
              C     IF GROUP BACK IS ALREADY ASSIGNED, GO TO NEXT GROUP.             CEL00990
0062                JS = JW-PXGR                                                     CEL01000
0063             120 IF (ASIN(JS)) GO TO 160                                         CEL01010
0064                CALL STU                                                         CEL01020
              C     COMPARE AGAINST ONE GROUP BACK.  IF IT IS DIFFERENT,             CEL01030
              C     TRANSFER TO PROCESSING OF NEXT GROUP.                            CEL01040
0065                IF (.NOT. SAME) GO TO 160                                        CEL01050
0066                ASIN(JS) = .TRUE.                                                CEL01060
0067                NFLD = RWFLD(JW)                                                 CEL01070
0068                RWFLD(JS) = NFLD                                                 CEL01080
0069                CALL ADD(NFLD,JS)                                                CEL01090
0070                JS = JS -PXGR                                                    CEL01100
              C                                                                      CEL01110
              C     CHECK TO SEE IF BACK AT BEGINNING OF ROW.                        CEL01120
0071                IF (JS .GE. W1) GO TO 120                                        CEL01130
0072                GO TO 160                                                        CEL01140
0073             130 IF (JW .EQ. W1) GO TO 160                                       CEL01150
              C     IF THIS GROUP DIFFERS FROM THE ONE ABOVE, ASK IF THE ONE         CEL01160
              C     TO ITS LEFT IS ASSIGNED AND IF SO COMPARE TO IT.                 CEL01170
              C                                                                      CEL01180
0074                IF (ASIN(JW-PXGR)) GO TO 135                                     CEL01190
0075                IF (JW .EQ. WL2) GO TO 140                                       CEL01200
              C     THE CODE IF PROVIDES FOR SPECIAL TREATMENT AT THE END OF A ROW.  CEL01210
0076                GO TO 160                                                        CEL01220
0077             135 JS = JW                                                         CEL01230
0078                CALL STR1                                                        CEL01240
0079                IF (SAME) GO TO 137                                              CEL01250
0080                IF (JW .EQ. WL2) GO TO 140                                       CEL01260
              C     THE IF ASKS IF END OF ROW.                                       CEL01270
0081                GO TO 160                                                        CEL01280
0082             137 ASIN(JW) = .TRUE.                                               CEL01290
0083                NFLD = RWFLD(JW-PXGR)                                            CEL01300
0084                RWFLD(JW) = NFLD                                                 CEL01310
0085                CALL ADD(NFLD,JW)                                                CEL01320
0086                GO TO 160                                                        CEL01330
0087             140 CALL SET                                                        CEL01340
0088                FSR(IFLD) = JLINE+1                                              CEL01350
              C     SPECIAL CODE FOR NEW FIELD AT END OF ROW.                        CEL01360
0089                ASIN(JW) = .TRUE.                                                CEL01370
0090                RWFLD(JW) = IFLD                                                 CEL01380
0091                IF (ASIN(JW-PXGR1)) GO TO 160                                    CEL01390
              C     IF ONE BACK IS ASSIGNED NO NEED TO COMPARE IT.                   CEL01400
              C                                                                      CEL01410
0092                JS = JW-PXGR                                                     CEL01420
0093             150 CALL STR                                                        CEL01430
0094                IF (.NOT. SAME) GO TO 160                                        CEL01440
              C     LOOP TO CHECK BACK ACROSS.                                       CEL01450
0095                ASIN(JS) = .TRUE.                                                CEL01460
0096                RWFLD(JS) = IFLD                                                 CEL01470
0097                CALL ADD(IFLD,JS)                                                CEL01480
0098                JS = JS-PXGR                                                     CEL01490
0099                IF (ASIN(JS)) GO TO 160                                          CEL01500
0100                IF (JS .GE. W1) GO TO 150                                        CEL01510
0101             160 CONTINUE                                                        CEL01520
              C                                                                      CEL01530
              C     FOLLOWING IS GOING BACK THROUGH ROW TO PICK UP ANY GROUPS        CEL01540
              C     NOT YET ASSIGNED AND CALLING THEM NEW FIELDS.                    CEL01550
0102                JW = WL3                                                         CEL01560
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0103             170 IF (ASIN(JW)) GO TO 190                                         CEL01570
0104                 ASIN(JW) = .TRUE.                                               CEL01580
0105                 CALL SET                                                        CEL01590
0106                 FSR(IFLD) = JLINE+1                                             CEL01600
0107                 RWFLD(JW) = IFLD                                                CEL01610
0108             180 JW = JW-PXGR                                                    CEL01620
0109                 IF (JW .LT. W1) GO TO 200                                       CEL01630
              C      IF AT START OF ROW THEN ARE FINISHED.                           CEL01640
              C                                                                      CEL01650
0110                 IF (ASIN(JW)) GO TO 190                                         CEL01660
0111                 JS = JW                                                         CEL01670
0112                 CALL STR                                                        CEL01680
              C      CHECK AGAINST ONE BEHIND IF IT IS NOT ASSIGNED.                 CEL01690
0113                 IF (.NOT. SAME) GO TO 170                                       CEL01700
              C      IF A NEW FIELD GO BACK AND ASSIGN.                              CEL01710
              C                                                                      CEL01720
0114                 ASIN(JW) = .TRUE.                                               CEL01730
0115                 RWFLD(JW) = IFLD                                                CEL01740
0116                 CALL ADD(IFLD,JW)                                               CEL01750
              C      NOW GO CHECK NEXT GROUP BACK ACROSS.                            CEL01760
0117                 GO TO 180                                                       CEL01770
0118             190 JW = JW-PXGR                                                    CEL01780
0119                 IF (JW .GE. W1) GO TO 170                                       CEL01790
0120             200 CALL PRINT                                                      CEL01800
0121                 DO 220 I = W1,WL2,PXGR                                          CEL01810
0122                 OPEN(OLDRW(I)) = .TRUE.                                         CEL01820
0123                 CLOSE(RWFLD(I)) = .FALSE.                                       CEL01830
0124             220 OLDRW(I) = RWFLD(I)                                             CEL01840
              C      RWFLD IS MOVED TO OLDRW FOR COMPARISONS FROM NEXT ROW.          CEL01850
              C      ALSO OPEN NOW INDICATES WHICH VECTORS OF AFLD ARE OPEN ON       CEL01860
              C      LAST ROW AND CLOSE INDICATES WHICH VECTORS ARE CLOSED           CEL01870
              C      ON CURRENT ROW.                                                 CEL01880
              C                                                                      CEL01890
0125                 DO 230 ICLOSE = 1,250                                           CEL01900
0126                 IF (OPEN(ICLOSE) .AND. CLOSE(ICLOSE)) CALL CLSTK                CEL01910
0127                 OPEN(ICLOSE) = .FALSE.                                          CEL01920
0128             230 CLOSE(ICLOSE) = .TRUE.                                          CEL01930
              C      FOR ALL FIELDS JUST CLOSED, CLASSIFICATION IS PERFORMED         CEL01940
              C      AND THE VECTOR OF AFLD RETURNED TO THE STACK.                   CEL01950
              C     THEN OPEN AND CLOSE ARE INITIALIZED FOR THE NEXT ROW.            CEL01960
              C                                                                      CEL01970
              C                                                                      CEL01980
              C      PRINTI IS CALLED TO PRINT RESULTS OF 50 ROWS.                   CEL01990
              C      PRINTI IS CALLED AFTER THE FRIST 100 ROWS HAVE BEEN PROCESSED   CEL02000
              C      TO PRINT THE FIRST FIFTY ROWS AND THEN AFTER EACH FIFTY ROWS    CEL02010
              C      HAVE BEEN PROCESSED TO PRINT AN ADDITIONAL 50 ROWS.             CEL02020
0129                 IF (JNR .GE. 100 .AND. MOD(JNR,50) .EQ. 0) CALL PRINTI          CEL02030
0130             250 CONTINUE                                                        CEL02040
0131                 JR = IR2+1                                                      CEL02050
0132                 CALL PRINTI                                                     CEL02060
              C      THIS CALL TO PRINTI WILL PRINT RESULTS OF ALL REMAINING         CEL02070
              C      ROWS.                                                           CEL02080
0133                 ATIME = FLOAT(ITIMER(OUT))/100.0                                CEL02090
              C      ATIME WILL CONTAIN TIME (VIRTUAL CPU TIME) SINCE THE            CEL02100
              C      CALL TO ITIMER IN STATEMENT 1.                                  CEL02110
0134                 WRITE (OUT,267) ATIME                                           CEL02120
0135             267 FORMAT (' TIME USED*',F8.2,' SECONDS*)                          CEL02130
0136                 STOP                                                            CEL02140
0137                 END
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0001                 SUBROUTINE PGROW                                                PGR00010
              C      READS A NEW ROW OF PIXEL GROUPS AND COMPUTES THE SUMS AND SUMS  PGR00020
              C      OF SQUARES OF VALUES OF EACH PIXEL GROUP.                       PGR00030
0002                 IMPLICIT  INTEGER*2  (E-Z)                                      PGR00040
0003                 INTEGER** QUT, IN, JNR, NS                                      PGR00050
0004                 LOGICAL*1  SAME, ASIN, ENOUGH, CLOSE, OPEN                      PGR00060
0005                 COMMON  ATOT(250,4), AFS(250,4), ASUM(250,4), ASQ(256,4), AT(4),PGR00070
                    1     AFLD(250), APGR), AST, APWR, OUT, IN, JNR, NS              PGR00080
0006                 COMMON /INT2/ PIXI(1280), RWFLD(1256), OLDRW(256), STACK(250),  PGR00090
                    1     FSR(250), LASTAT(130), SPI(130,100), PXGR, PXGR1, NCHAN ,  PGR00100
                    2     ROWS, W1, W2, WL2, WIDE, NFS, JW, JS, JR, KL1, IFLD, SIGLEV,PGR00110
                    3     IDF, 81, 82, IR1, IR2, ICLOSE, PCLASS, PWIDE, NEXT, JLINE PGR00120
0007                 COMMON /RESULT/ SAME, ASIN(256), ENOUGH(250), CLOSE(250),OPEN(250)PGR00130
0008                 LOGICAL*1 DATA(1280,4), DUMC                                    PGR00140
0009                 LOGICAL*1 DATA1(2740)                                           PGR00150
0010                 INTEGER*4 ID,LVID,ERRRV,RUNNUM                                  PGR00160
0011                 COMMON /LABS/ ID(200),RUNNUM,RCSEL(30),COV(256,6),              PGR00170
                    1     AFCV(250,6)                                                PGR00180
0012                 DIMENSION PIXEL(768,4)                                          PGR00190
0013                 L1 = 1                                                          PGR00200
0014                 L2 = WIDE                                                       PGR00210
0015                 WO = W1-1                                                       PGR00220
0016                 DO 30 I = 1,PXGR                                                PGR00230
0017                 CALL TOPRV(1,1,ID(6),ERRRV,IDATA,2,ID(5),RCSEL,LNID)            PGR00240
0018                 IF (ERRRV .EQ. 1) STOP 10                                       PGR00250
0019                 IF (ERRRV .NE. 0) WRITE (15,15) ERRRV                           PGR00260
0020              15 FORMAT (' ERROR *',I8)                                          PGR00270
0021                 DO 20 NS = 1,NCHAN                                              PGR00280
0022                 K = (NS-1)*ID(6)                                                PGR00290
0023                 KK = 1                                                          PGR00300
0024                 DO 20 J = W1,W2                                                 PGR00310
0025                 DATA(KK,NS) =IDATA(K+J)                                         PGR00320
0026              20 KK = KK+1                                                       PGR00330
0027                 L1 = L2+1                                                       PGR00340
0028                 L2 = L2+WIDE                                                    PGR00350
0029                 WORDS =WIDE*PXGR                                                PGR00360
0030                 DO 100 NS = NCHAN                                               PGR00370
0031                 CALL SHIFT (PIXEL(1,NS),DATA(1,NS),WORDS)                       PGR00380
0032                 L = -PXGR                                                       PGR00390
0033                 DO 50 JW = W1,WL2,PXGR                                          PGR00400
0034                 L = L+PXGR                                                      PGR00410
0035                 ASUM(JW,NS) = 0.0                                               PGR00420
0036                 ASQ(JW,NS) = 0.0                                                PGR00430
0037                 KK = 1                                                          PGR00440
0038                 DO 50 I = 1,PXGR                                                PGR00450
0039                 DO 40 J = 1,PXGR                                                PGR00460
0040                 ASUM(JW,NS) = ASUM(JW,NS)+PIXEL(KK+J,NS)                        PGR00470
0041              40 ASQ(JW,NS) = ASQ(JW,NS) + PIXEL(KK+J,NS)**2                     PGR00480
0042              50 KK = KK+WIDE                                                   PGR00490
0043             100 CONTINUE                                                       PGR00500
0044                 NS1 = NS-PTRA-1                                                 PGR00510
0045                 L1 = 0                                                          PGR00520
0046                 DO 110 NS = 1,NS1                                               PGR00530
0047                 L2 = NS+1                                                       PGR00540
0048                 DO 110 NS1 = L2,NCHAN                                           PGR00550
0049                 L1 = L1+1                                                       PGR00560
0050                 L = -PXGR                                                       PGR00570
0051                 DO 110 JW = W1,WL2,PXGR                                         PGR00580
0052                 L = L+PXGR                                                      PGR00590
0053                 COV(JW,L1) = 0.0                                                PGR00600
0054                 KK = 1                                                          PGR00610
0055                 DO 105 I = 1,PXGR                                               PGR00620
0056                 DO 105 J = 1,PXGR                                               PGR00630
0057             105 COV(JW,L1) = COV(JW,L1) + PIXEL(KK+J,NS)*PIXEL(KK+J,NS1)       PGR00640
0058             110 KK = KK+WIDE                                                   PGR00650
              C      THE DO 110 LOOPS COMPUTE THE COVARIANCE MATRIX FOR EACH PIXEL GROUPGR00660
              C      ON THIS ROW                                                     PGR00670
                     RETURN                                                          PGR00680
0059                 ENTRY RDOVER                                                    PGR00690
0060          C      ENTRY RDOVER READS OVER ROWS OF THE PICTURE WHICH ARE NOT       PGR00700
              C      TO BE PROCESSED.                                                PGR00710
0061          C      IF (R1 .LE. 1) RETURN                                           PGR00720
              C      IF R1 IS 1, THEN NO ROWS NEED TO BE READ OVER.                  PGR00730
0062                 L1 = R1-1                                                       PGR00740
0063                 DO 120 I = 1,L1                                                 PGR00750
0064             120 CALL TOPRV(1,1,ID(6),ERRRV,IDATA,2,ID(5),RCSEL,LNID)            PGR00760
0065                 RETURN                                                          PGR00770
0066                 END                                                             PGR00780
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0001                SUBROUTINE ADD (INTO,FROM)                                  ADD00010
                C   ADD ADDS A NEW PIXEL GROUP INTO AFTOT AND AFS.               ADD00020
                C   INTO IS THE ROW OF AFTOT AND AFS CONTAINING                 ADD00030
                C   THE FIELD TO BE ADDED INTO. FROM CONTAINS THE               ADD00040
                C   ELEMENT OF ASUM AND ASQ CONTAINING THE CURRENT PIXEL        ADD00050
                C   GROUP WHICH IS BEING ADDED.                                 ADD00060
0002                IMPLICIT  INTEGER*2 (E-Z)                                   ADD00070
0003                INTEGER*4  OUT, IN, JNR, NS                                 ADD00080
0004                LOGICAL*1  SAME, ASIN, ENOUGH, CLOSE, OPEN                  ADD00090
0005                COMMON  AFTOT(250,4), AFS(250,4), ASUM(250,4), ASQ(256,4), AT(4),  ADD00100
                   1    AFLD(250), APGR(), AST, APGR, OUT, IN, JNR, NS          ADD00110
0006                COMMON /INT2/ PIX(1280), RWFLD(256), OLDRW(256), STACK(250),  ADD00120
                   1    FSR(250), LAST(130), SPI(130,100), PXGR, PXGRI, NCHAN   ADD00130
                   2    ROWS, W1, W2, WL2, WIDE, MFS, JW, J3, JR, RLI, IFLD, SIGLEV,  ADD00140
                   3    IDF, R1, R2, IR1, IR2, ICLOSE, PCLASS, PWIDE, NEXT      ADD00150
0007                COMMON /RESULT/ SAME, ASIN(256), ENOUGH(250), CLOSE(250),DPEN(250)ADD00160
0008                INTEGER*4  ID, RUNNUM                                       ADD00170
0009                COMMON /LARS/ ID(200), RUNNUM, RCSEL(30),COV(256,61),       ADD00180
                   1    AFCOV(250,6)                                            ADD00190
0010                NG = (NSQTRA**2-NCHAN )/2                                   ADD00195
0011                AFLD(INTO) = AFLD(INTO) + 1.0                               ADD00200
0012                DO 50 NS = 1,NCHAN                                          ADD00210
0013                AFTOT(INTO,NS) = AFTOT(INTO,NS) + ASUM(FROM,NS)             ADD00220
0014                AFS(INTO,NS) = AFS(INTO,NS)+ASQ(FROM,NS)                    ADD00230
0015                DO 60 L1 = 1,NC                                             ADD00240
0016             60 AFCOV(INTO,L1) = AFCOV(INTO,L1) + COV(FROM,L1)              ADD00300
                C   THE DO 60 LOOPS ADD THE COVERARIANCE MATRIX FOR             ADD00310
                C   THE GROUP INTO THAT OF THE FIELD                           ADD00320
0017                RETURN                                                      ADD00330
0018                ENTRY SET                                                   ADD00340
                C   WHEN A NEW FIELD IS STARTED, A NUMBER IS PULLED FROM        ADD00350
                C   THE STACK OF AVAILABLE VECTORS OF AFTOT AND AFS             ADD00360
                C   (AND ELEMENT OF AFLD). THIS VECTOR IS USED FOR THE NEW FIELD.  ADD00370
0019                IFLD = STACK(NEXT)                                          ADD00380
0020                NEXT = NEXT +1                                              ADD00390
0021                NC = (NCHAN **2-NCHAN )/2                                   ADD00395
0022                AFLD(IFLD) = 1.0                                            ADD00400
0023                DO 100 NS = 1,NCHAN                                         ADD00410
0024                AFTOT(IFLD,NS) = ASUM(JW,NS)                                ADD00420
0025             100 AFS(IFLD,NS) = ASQ(JW,NS)                                  ADD00430
0026                DO 110 L1 = 1,NC                                            ADD00440
0027             110 AFCOV(IFLD,L1) = COV(JW,L1)                                ADD00450
0028                RETURN                                                      ADD00460
0029                ENTRY CLSTK                                                 ADD00470
                C   ENTRY CLSTK CLOSES OUT A CLEMENT OF AFLD BY RETURNING      ADD00480
                C   IT TO STACK, CLASSIFYING THE FIELD AND ZEROING             ADD00490
                C   AFLD AND THE ROW OF AFTOT AND AFS USED FOR THE CLOSED FIELD.  ADD00500
0030                NEXT = NEXT -1                                              ADD00510
0031                STACK(NEXT) = ICLOSE                                        ADD00520
0032                CALL CLASS                                                  ADD00530
0033                DO 200 J = 1,4                                              ADD00540
0034                AFTOT(ICLOSE,J) = 0.0                                       ADD00550
0035             200 AFS(ICLOSE,J) = 0.0                                        ADD00560
0036                DO 210 J = 1,6                                              ADD00570
0037             210 AFCOV(ICLOSE,J) = 0.0                                      ADD00580
0038                AFLD(ICLOSE) = 0.0                                          ADD00640
0039                RETURN                                                      ADD00650
0040                END                                                         ADD00660
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0001                FUNCTION ITIMER (J)                                         ITI00010
0002                ITIMER = 0                                                  ITI00020
0003                RETURN                                                      ITI00030
0004                END                                                         ITI00040
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0001                SUBROUTINE CLASS                                            CLA00010
                C   CLASS CLASSIFIES A CLOSED FIELD. THE ELEMENT OF AFLD WITH THE  CLA00020
                C   RELAVENT DATA IS ICLOSE. CLASS ALSO ALTERS THE SP PRINT OUT  CLA00030
                C   ARRAY TO REFLECT THE CLASSIFICATION.                        CLA00040
                C * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * CLA00050
                C   THE DUMMY PER FIELD CLASSIFIER BEGINS WITH THE FIRST EXECUTABLE  CLA00060
                C   STATEMENT AND CONTINUES TO (BUT NOT INCLUDING STATEMENT 150.  CLA00070
                C   THE CODE FROM STATEMENT 150 ON PROPAGATES THE CLASSIFICATION  CLA00080
                C   INDEX THROUGHOUT THAT PART OF THE SP PRINTOUT ARRAY WHICH    CLA00090
                C   REPRESENTS THIS FIELD.                                       CLA00100
                C * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * CLA00110
0002                IMPLICIT  INTEGER*2 (E-Z)                                   CLA00120
0003                INTEGER*4  OUT, IN, JNR, NS                                 CLA00130
0004                LOGICAL*1  SAME, ASIN, ENOUGH, CLOSE, OPEN                  CLA00140
0005                COMMON  AFTOT(250,4), AFS(250,4), ASUM(256,4), ASQ(256,4), AT(4),  CLA00150
                   1    AFLD(250), APGR(), AST, APGR, OUT, IN, JNR, NS          CLA00160
0006                COMMON /INT2/ PIX(1280), RWFLD(256), OLDRW(256), STACK(250),  CLA00170
                   1    FSR(250), LAST(130), SPI(130,100), PXGR, PXGRI, NCHAN   CLA00180
                   2    ROWS, W1, W2, WL2, WIDE, MFS, JW, J3, JR, RLI, IFLD, SIGLEV,  CLA00190
                   3    IDF, R1, R2, IR1, IR2, ICLOSE, PCLASS, PWIDE, NEXT, JLINE  CLA00200
0007                COMMON /RESULT/ SAME, ASIN(256), ENOUGH(250), CLOSE(250),DPEN(250)CLA00210
0008                LOGICAL*1 NXTRW                                             CLA00220
0009                DATA NCLASS /256/                                           CLA00230
0010                INTEGER*4 ID,RUNNUM                                         CLA00240
0011                COMMON /LARS/ ID(200), RUNNUM, RCSEL(30), COV(256,6),       CLA00250
                   1    AFCOV(250,6)                                            CLA00260
                C                                                               CLA00270
                C                                                               CLA00280
0012                AMFS = MFS                                                  CLA00290
0013                IF (AFLD(ICLOSE) .GE. AMFS) GO TO 120                       CLA00300
                C   FIELDS WITH LESS THAN MFS (MFS IS THE MINIMUM FIELD SIZE    CLA00310
                C   INPUT INTO SUBROUTINE GETPAM) PIXEL GROUPS ARE NOT CLASSIFIED.  CLA00320
0014                PCLASS = 304                                                CLA00330
0015                GO TO 130                                                   CLA00340
0016             120 NCLASS = NCLASS + 1                                        CLA00350
0017                IF (NCLASS .EQ. 304) NCLASS = 257                           CLA00360
0018                PCLASS = NCLASS                                             CLA00370
0019             130 J = FSR(ICLOSE)                                            CLA00380
0020             270 NXTRW = .FALSE.                                            CLA00390
0021                DO 280 I = 1,PWIDE                                          CLA00400
0022                IF (SPI(I,J) .NE. ICLOSE) GO TO 280                         CLA00410
0023                SPI(I,J) = PCLASS                                           CLA00420
0024                NXTRW = .TRUE.                                              CLA00430
0025             280 CONTINUE                                                   CLA00440
0026                I = I+1                                                     CLA00450
0027                IF (NXTRW .AND. J .LE. JLINE) GO TO 270                     CLA00460
0028             350 CONTINUE                                                   CLA00470
                C   THE DO 350 LOOP PROPAGUATES THE CLASSIFICATION INDEX       CLA00480
                C   PLUS 256 FOR THIS FIELD THROUGHOUT ALL ELEMENTS OF          CLA00490
                C   SP REPRESENTING THE FIELD.                                  CLA00500
0029                RETURN                                                      CLA00510
0030                END                                                         CLA00520
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0001                SUBROUTINE STU                                              STU00010
                C   THE STATISTICAL SUBROUTINE FOR T-TEST. RETURNS SAME = TRUE IF  STU00020
                C   TWO GROUPS BEING COMPARED ARE THE SAME.                     STU00030
                C   ENTRY STU COMPARES A PIXEL GROUP WITH THE FIELD CONTAINING  STU00040
                C   THE PIXEL GROUP IMMEDIATELY ABOVE THE CURRENT PIXEL GROUP..  STU00050
                C                                                               STU00060
                C   J CONTAINS THE ELEMENT OF AFLD REPRESENTING SAMPLE 2 IN THE  STU00070
                C   PAPER. JS IS THE INDEX OF THE CURRENT PIXEL GROUP. NOTE     STU00080
                C   THAT JS IS PASSED TO THIS SUBROUTINE VIA COMMON WHEREAS     STU00090
                C   J IS COMPUTED DIFFERENTLY ACCORDING TO WHICH                STU00100
                C   ENTRY POINT IS USED.                                        STU00110
                C                                                               STU00120
0002                IMPLICIT  INTEGER*2 (E-Z)                                   STU00130
0003                INTEGER*4  OUT, IN, JNR, NS                                 STU00140
0004                LOGICAL*1  SAME, ASIN, ENOUGH, CLOSE, OPEN                  STU00150
0005                COMMON  AFTOT(250,4), AFS(250,4), ASUM(256,4), ASQ(256,4), AT(4),  STU00160
                   1    AFLD(250), APGR(), AST, APGR, OUT, IN, JNR, NS          STU00170
0006                COMMON /INT2/ PIX(1280), RWFLD(256), OLDRW(256), STACK(250),  STU00180
                   1    FSR(250), LAST(130), SPI(130,100), PXGR, PXGRI, NCHAN   STU00190
                   2    ROWS, W1, W2, WL2, WIDE, MFS, JW, J3, JR, RLI, IFLD, SIGLEV,  STU00200
                   3    IDF, R1, R2, IR1, IR2, ICLOSE, PCLASS, PWIDE, NEXT      STU00210
0007                COMMON /RESULT/ SAME, ASIN(256), ENOUGH(250), CLOSE(250),DPEN(250)STU00220
0008                DIMENSION ATSTAT(34,4)                                      STU00230
0009                DATA ATSTAT /12.706, 4.303, 3.182, 2.776, 2.571, 2.447, 2.365,  STU00240
                   1    2.306, 2.262, 2.228, 2.201, 2.179, 2.160, 2.145, 2.131, 2.120,  STU00250
                   2    2.220, 2.101, 2.093, 2.086, 2.080, 2.074, 2.069, 2.064, 2.060,STU00260
                   3    2.056, 2.052, 2.048, 2.045, 2.042, 2.021, 2.000, 1.980, 1.960,STU00270
                   4    31.821, 6.965, 4.541, 3.747, 3.365, 3.143, 2.998, 2.896,   STU00280
                   5    2.821, 2.764, 2.718, 2.681, 2.650, 2.624, 2.602, 2.583,    STU00290
                   6    2.567, 2.552, 2.539, 2.528, 2.518, 2.508, 2.500, 2.492,    STU00300
                   7    2.485, 2.479, 2.473, 2.467, 2.462, 2.457, 2.423, 2.390,    STU00310
                   8    2.358, 2.326/                                           STU00320
                   9    63.657, 9.925, 5.841, 4.604, 4.032, 3.707, 3.499, 3.355,   STU00330
                   A    3.250, 3.169, 3.106, 3.055, 3.012, 2.977, 2.947, 2.921,    STU00340
                   B    2.898, 2.878, 2.861, 2.845, 2.831, 2.819, 2.807, 2.797,    STU00350
                   C    2.787, 2.779, 2.771, 2.763, 2.756, 2.750, 2.704, 2.660,    STU00360
                   D    2.617, 2.576                                            STU00370
                   E    636.619, 31.598, 12.941, 8.610, 6.859, 5.959, 5.405, 5.041,  STU00380
                   F    4.781, 4.587, 4.437, 4.318, 4.221, 4.140, 4.073, 4.015,    STU00390
                   G    3.965, 3.922, 3.883, 3.850, 3.819, 3.792, 3.767, 3.745, 3.725,STU00400
                   H    3.707, 3.690, 3.674, 3.659, 3.646, 3.551, 3.460, 3.373, 3.291/STU00410
0010                J = OLDRW(JW)                                               STU00420
0011                GO TO 10                                                    STU00430
0012                ENTRY STR                                                   STU00440
                C   ENTRY STR COMPARES A GROUP WITH THE FIELD CONTAINING       STU00450
                C   THE PIXEL GROUP TO THE RIGHT OF THE CURRENT GROUP.          STU00460
0013                J = RWFLD(JS+PXGR)                                          STU00470
0014                GO TO 10                                                    STU00480
0015                ENTRY STRI                                                  STU00490
                C   ENTRY STRI COMPARES A FILED CONTAINING A GIVEN PIXEL GROUP  STU00500
                C   TO THE GOURP IMMEDIATELY TO ITS RIGHT.                      STU00510
0016                J = RWFLD(JS-PXGR)                                          STU00520
0017             10 AN1 = AFLD(J)*APGR                                          STU00530
                C   AN1 IS NUMBER OF PIXELS IN FIELD CURRENT PIXEL GROUP IS BEING  STU00540
                C   COMPARED TO.                                               STU00550
0018                BNUMB = AN1+APGR-2.0                                        STU00560
0019                DO 25 NS = 1,NCHAN                                          STU00570
0020                AV1 = ASUM(JS,NS)/APGR                                      STU00580
0021                AV2 = AFTOT(J,NS)/AN1                                       STU00590
                C   AV1 AND AV2 ARE THE MEANS OF THE SAMPLES.                   STU00600
0022                D1 = ASQ(JS,NS)-ASUM(JS,NS)**2/APGR                         STU00610
0023                D2 = AFS(J,NS)-AFTOT(J,NS)**2/AN1                           STU00620
                C   D1 AND D2 ARE THE VARIANCES OF THE TWO SAMPLES. IN THE     STU00630
                C   FOLOWING LOGIC THE STANDARD DEVIATIONS OF THE SAMPLES      STU00640
                C   ARE COMPARED TO THE MEANS. IF EITHER STANDARD DEVIATION    STU00650
                C   IS LARGER THAN 15% OF THE MEAN, SAME = .FALSE. IS RETURNED.  STU00660
0024                IF (D1 .EQ. 0.0) GO TO 12                                   STU00670
0025                IF (SQRT(D1* APGR) .GT. .15*AV1) GO TO 15                   STU00680
0026             12 IF (D2 .EQ. 0.0) GO TO 18                                   STU00690
0027                IF (SQRT(D2/AN1) .LE. .15*AV2) GO TO 18                     STU00700
0028             15 SAME = .FALSE.                                              STU00710
0029                RETURN                                                      STU00720
0030             18 ASP = (D1+D2)/BNUMB                                         STU00730
0031                IF (ASP .NE. 0.0) GO TO 20                                  STU00740
                C   ASP IS THE SP**2 IN THE PAPER                               STU00750
0032                AT(NS) = 6.0                                                STU00760
0033                GO TO 25                                                    STU00770
0034             20 AT(NS) = (AV1-AV2)/SQRT(ASP*(1.0/AN1+APGR)))                STU00780
```

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0035            25 CONTINUE                                                    STU00790
0036            30 IDT = BNUMB                                                 STU00800
0037               IF (IDT .GT. 30) IDT = 30                                   STU00810
0038               IF (IDF .LE. 30) GO TO 40                                   STU00820
0039               IF (IDF .LE. 40) GO TO 39                                   STU00830
0040               IF (IDF .LE. 60) GO TO 38                                   STU00840
0041               IF (IDF .LE. 120) GO TO 37                                  STU00850
0042               IDT = IDT+1                                                 STU00860
0043            37 IDT = IDT+1                                                 STU00870
0044            38 IDT = IDT+1                                                 STU00880
0045            39 IDT = IDT+1                                                 STU00890
C                  THE ABOVE LOGIC GETS THE CORRECT INDEX FOR THE NUMBER OF DEGREES  STU00900
C                  OF FREEDOM.                                                 STU00910
0046            40 SAME = .TRUE.                                               STU00920
0047               DO 60 NS = 1,NCHAN                                          STU00930
0048               IF (ABS(ATIN(NS)) .GT. ATSTAT(IDF,SIGLEV)) SAME = .FALSE.   STU00940
C                  IF THE VALUE OF T (ATIN(S)) IS GREATER THAN THE CRITERION VALUE  STU00950
C                  FOR THE T FOR ANY SPECRAL THEN THE NULL HYPOTHESIS THAT     STU00960
C                  THE TWO SAMPLES ARE THE SAME IS REJECTED.                   STU00970
0049               RETURN                                                      STU00980
0050               END                                                         STU00990
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0041            210 FORMAT (' ',4x,14, 1i4a1)                                  PRI00790
0042                IF (JR .EQ. IR2+1) RETURN                                  PRI00800
C                   THIS IF WILL CAUSE A RETURN WITHN THE LAST CALL TO         PRI00810
C                   IS BEING EXECUTED. (JR WAS SET TO IR2+1 IN MAIN JUST       PRI00820
C                   BEFORE THE LAST CALL TO PRINT1.)                           PRI00830
0043                DO 300 I = 1,PWIDE                                         PRI00840
0044                LAST(I) = SP(I,50)                                         PRI00850
C                   LASTR IS THE LAST ROW FROM THIS PRINT. IT IS ARRANGED      PRI00860
C                   IN COMMON AS THE ZEROETH VECTOR OF SP SO THAT              PRI00870
C                   IT IS AVAILABLE FOR COMPARISONS THE NEXT TIME              PRI00880
C                   PRINT1 IS CALLED.                                          PRI00890
C                                                                              PRI00900
0045                DO 300 J = 1,50                                            PRI00910
0046            300 SP(I,J) = SP(I,J+50)                                       PRI00920
C                   UNPRINTED ROWS OF RESULTS ARE  MOVED TO THE FIRST 50       PRI00930
C                   ROWS OF THE SP PRINT ARRAY.                                PRI00940
0047                DO 310 J = 1,50                                            PRI00950
0048            310 FSR(J) = FSR(J) -50                                        PRI00960
C                   ELEMENTS OF FSR MUST CORRESPOND TO THE NEW PLACEMENT OF ROWS  PRI00970
C                   IN SP. THUS THE DO 310 LOOP ALTERS FSR.                    PRI00980
0049                FIRST = .FALSE.                                            PRI00990
C                   FIRST = .FLASE. INDICATES TO FUTURE CALLS TO PRINT1        PRI01000
C                   THAT PRINT1 HAS BEEN CALLED PREVIOUSLY. THE DIFFERENCE     PRI01010
C                   IN THE FIRST CALL IS THAT THE FIRST LINE IS A BOUNDARY.    PRI01020
0050                JLINE = 50                                                 PRI01030
0051                RETURN                                                     PRI01040
0052                ENTRY PRINTO                                               PRI01050
C                    ENTRY PRINTO PRINTS THE HEADING AND INITIALIZES JLINE     PRI01060
C                   AND FIRST.                                                 PRI01070
0053                WRITE (OUT,420) MFS,PXGR, PXGR, SIGLEV, NCHAN              PRI01080
0054            420 FORMAT (' MIN. NO. OF PIXEL GROUPS CALLED A FIELD ='       PRI01090
                   1    ,i3/' PIXEL GROUP SIZE IS ',i1,' X ',i1,               PRI01100
                   2    ' SIGNIFICANCE LEVEL = ',f4.3,                         PRI01110
                   3    ' NUMBER OF SPECTRA = ',i2/)                           PRI01120
0055                J = 0                                                      PRI01130
0056                DO 430 JW = W1,W2,PXGR                                     PRI01140
0057                J = J+1                                                    PRI01150
0058                PRNT(J) = EMPTY                                            PRI01160
0059                P1(J) = EMPTY                                              PRI01170
0060                IF (JW .GT. 99) PRNT(J) = HEAD(MOD(JW/100,100)+1)          PRI01180
0061                IF (JW .GT. 9) P1(J) = HEAD(MOD(JW/10,10)+1)               PRI01190
0062            430 P2(J) = HEAD(MOD(JW+0,10)+1)                               PRI01200
0063                WRITE (OUT,440) (PRNT(J),J=1,PWIDE)                        PRI01210
0064                WRITE (OUT,440) (P1(J),J=1,PWIDE)                          PRI01220
0065                WRITE (OUT,440) (P2(J),J=1,PWIDE)                          PRI01230
0066            440 FORMAT (' ',4x,1i4a1)                                      PRI01240
0067                JRLINE = -PXGR+1                                           PRI01250
0068                FIRST = .TRUE.                                             PRI01260
0069                RETURN                                                     PRI01270
0070                END                                                        PRI01280
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0001                SUBROUTINE PRINT                                           PRI00010
0002                IMPLICIT  INTEGER*2  (E-Z)                                 PRI00020
0003                INTEGER*4  OUT, IN, JNR, NS                                PRI00030
0004                LOGICAL*1  SAME, ASIN, ENOUGH, CLOSE, OPEN                 PRI00040
0005                COMMON  AFIQT(250,4), AFS(250,4), ASUM(256,4), ASQ(256,4), AT(4),  PRI00050
                   1    AFLD(250), APGR(), AST, APGR, OUT, IN, JNR, NS         PRI00060
0006                COMMON /INT2/ PIX(1280), RWFLD(256), OLDRWI(256), STACK(250),  PRI00070
                   1    FSR(250), LASTR(130), SPI(130,100), PXGR, PXGRI, NCHAN,  PRI00080
                   2    ROWS, W1, W2, WL2, WIDE, MFS, JW, J1, JR, RL1, IFLD, SIGLEV,  PRI00090
                   3    IDF, R1, R2, IR1, IR2, ICLOSE, PCLASS, PWIDE, NEXT, JLINE  PRI00100
0007                COMMON /RESULT/ SAME, ASIN(256), ENOUGH(250), CLOSE(250),OPEN(250)PRI00110
0008                DIMENSION NUMBER(48), PRNTI(130), HEAD(10), PI(130), P2(130)   PRI00120
0009                EQUIVALENCE (ASUM(1),PI(1)), (ASQ(1),P2(1))                PRI00130
0010                LOGICAL*1 FIRST                                            PRI00140
0011                DATA HEAD / '0', '1', '2', '3', '4', '5', '6',             PRI00150
                   1    '7', '8', '9', ' ' /                                   PRI00160
0012                DATA EMPTY /' ', ' ' /                                     PRI00170
0013                DATA NUMBER                                                PRI00180
                   .    /'A', 'B', 'C', 'D', 'E', 'F', 'G', 'H', 'I', 'J',     PRI00190
                   .    'K', 'L', 'M', 'N', 'O', 'P', 'Q', 'R', 'S', 'T', 'U', 'V',  PRI00200
                   .    'W', 'X', 'Y', 'Z', '1', '2', '3', '4', '5', '6', '7', '8',  PRI00210
                   .    '9', '0', '(', ')', '+', '-', '*', '/', '=', '.',     PRI00220
                   .    ' ', ',', '$', '*' /                                   PRI00230
                   .                                                           PRI00240
C                                                                              PRI00250
C                   ENTRY TO PRINT MERELY STORES RESULTS OF THE CURRENT ROW INTO  PRI00260
C                   THE PRINT ARRAY, SP.                                       PRI00270
0014                JLINE = JLINE+1                                            PRI00280
0015                J = 0                                                      PRI00290
0016                DO 100 J = W1,WL2,PXGR                                     PRI00300
0017                I = I+1                                                    PRI00310
0018            100 SPI(JLINE) = RWFLD(J)                                      PRI00320
0019                RETURN                                                     PRI00330
0020                ENTRY PRINT1                                               PRI00340
C                   ENTRY PRINT1 ACTUALLY PRINTS RESULTS OF A NUMBER OF ROWS.  PRI00350
C                   BEFORE PRINTING, ANY FIELDS WHICH ARE OPEN ON THE LAST     PRI00360
C                   ROW TO BE PRINTED ARE CLASSIFIED (NOT CLOSED).             PRI00370
0021                JLAST = MOD(JNR,50)+50                                     PRI00380
0022                IF (JNR .LT. 50) JLAST = JNR                               PRI00390
0023                J = 0                                                      PRI00400
0024                DO 110 JW = W1,WL2,PXGR                                    PRI00410
0025                J = J+1                                                    PRI00420
0026                IF (SPI(J,JLAST) .GE. 256) GO TO 110                       PRI00430
C                   WHEN A FIELD IS CLOSED, SP IS SET TO THE FIELD IDENTIFICATION  PRI00440
C                   INDEX PLUS 256. THUS ONLY THOSE FIELDS WITH ENTRIES IN SP  PRI00450
C                   OF LESS THAN 256 ARE STILL OPEN.                           PRI00460
0027                ICLOSE = RWFLD(JW)                                         PRI00470
C                   SUBROUTINE CLASS ASSUMES THAT ICLOSE CONTAINS THE ELEMENT OF  PRI00480
C                   AFLD TO BE CLASSIFIED.                                     PRI00490
0028                CALL CLASS                                                 PRI00500
0029                FSR(ICLOSE) = 101                                          PRI00510
0030            110 CONTINUE                                                   PRI00520
C                   FSR SHOULD BE EQUAL TO THE FIRST ROW OF A FIELD WHICH      PRI00530
C                   NEEDS TO HAVE ITS ENTRIES IN THE SP ARRAY PROCESSED.       PRI00540
C                   SINCE THOSE ROWS OF THIS FIELD DOWN TO ROW JR              PRI00550
C                   ARE ABOUT TO BE PRINTED, THE NEXT ROW OF THIS FIELD        PRI00560
C                   WHICH WILL HAVE ACTIVE ENTRIES IN SP IS RUN JR+PXGR.       PRI00570
C                                                                              PRI00580
C                   ALL FIELDS UNCLASSIFIED IN THE AREA TO BE PRINTED ARE      PRI00590
C                   CLASSIFIED.                                                PRI00600
C                                                                              PRI00610
0031                DO 200 PLINE = 1,JLAST                                     PRI00620
0032                JRLINE = JRLINE + PXGR                                     PRI00630
0033                DO 160 J = 1,PWIDE                                         PRI00640
0034                SPK = SPI(J,PLINE)                                         PRI00650
0035                IF (J .EQ. 1 .OR. J .EQ. PWIDE .OR. JR .EQ. IR2+1 .AND.    PRI00660
                   1    PLINE .EQ. JLAST .OR. FIRST .AND. PLINE .EQ. 1) GO TO 150  PRI00670
0036                PRNT(J) = EMPTY                                            PRI00680
0037                IF (SPK .EQ. SPI(J-1,PLINE+1) .AND. SPK .EQ. SPI(J,PLINE-1)  PRI00690
                   1    .AND. SPK .EQ. SPI(J+1,PLINE) .AND. SPK .EQ. SPI(J-1,PLINE))  PRI00700
                   2    GO TO 160                                              PRI00710
0038            150 PRNT(J) = NUMBER(SPK+256)                                  PRI00720
0039            160 CONTINUE                                                   PRI00730
C                   THE DO 160 LOOP SETS UP A LINE TO BE PRINTED.              PRI00740
C                   THE VECTOR PRNT CONTAINS THE TEXT OF THE LINE TO BE PRINTED.  PRI00750
C                   THE LINE CONTAINS BLANKS EXCEPT FOR BOUNDARIES OF FIELDS   PRI00760
C                   ON BOUNDARIES, THE FIELD IDENTIFICATION CHARACTER IS PRINTED.  PRI00770
0040            200 WRITE (OUT,210) JRLINE, (PRNT(J),J=1,PWIDE)                PRI00780
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0001                SUBROUTINE GETPRM                                          GET00010
C                   GETPRM READS IN VARIABUS PARAMETERS. THE FIRST IS THE INPUT  GET00020
C                   UNIT NUMBER FROM WHICH THE REMAINING PARAMETERS ARE        GET00030
C                   TO BE READ.                                                GET00040
C                   THEN COMES THE TITLE, PIXEL GROUP SIZE, ROWS AND           GET00050
C                   COLUMNS TO BE PROCESSED, SIGNIFICANCE LEVEL, MINIMUM FIELD  GET00060
C                   SIZE, NUMBER OF SPECTRA AND THE UNIT NUMBER                GET00070
C                   TO WHICH THE OUTPUT IS TO BE WRITTEN. OTHER INITIALAZATION  GET00080
C                   FUNCTIONS ARE ALSO PERFORMED.                              GET00090
0002                IMPLICIT  INTEGER*2  (E-Z)                                 GET00100
0003                INTEGER*4  OUT, IN, JNR, NS                                GET00110
0004                LOGICAL*1  SAME, ASIN, ENOUGH, CLOSE, OPEN                 GET00120
0005                COMMON  AFIQT(250,4), AFS(250,4), ASUM(256,4), ASQ(256,4), AT(4),  GET00130
                   1    AFLD(250), APGR(), AST, APGR, OUT, IN, JNR, NS         GET00140
0006                COMMON /INT2/ PIX(1280), RWFLD(256), OLDRWI(256), STACK(250),  GET00150
                   1    FSR(250), LASTR(130), SPI(130,100), PXGR, PXGRI, NCHAN,  GET00160
                   2    ROWS, W1, W2, WL2, WIDE, MFS, JW, J1, JR, RL1, IFLD, SIGLEV,  GET00170
                   3    IDF, R1, R2, IR1, IR2, ICLOSE, PCLASS, PWIDE, NEXT, JLINE  GET00180
0007                COMMON /RESULT/ SAME, ASIN(256), ENOUGH(250), CLOSE(250),OPEN(250)GET00190
0008                INTEGER*4 ID,RUNNUM,ERRGRN                                 GET00200
0009                COMMON /LAST/ ID(200),RUNNUM,RCSEL(30)                     GET00210
0010                DATA ATT/'?'/                                              GET00220
C                   WRITE (15,2)                                               GET00230
C                   READ (15,65) IN                                            GET00240
0011            5 FORMAT (' INPUT ')                                           GET00250
0012                IN=5                                                       GET00260
0013                IF (IN .EQ. 15) WRITE (15,6)                               GET00270
0014            6 FORMAT (' RUN IDENTIFIER ')                                  GET00280
0015                READ (IN,7) (AFS(I),I=1,4)                                 GET00290
0016            7 FORMAT (4A4)                                                 GET00300
0017                IF (IN .EQ. 15) WRITE (15,10)                              GET00310
0018           10 FORMAT (' GROUP SIZE ')                                      GET00320
0019                READ (IN,15) PXGR                                          GET00330
0020           15 FORMAT (I1)                                                  GET00340
0021                IF (IN .EQ. 15) WRITE (15,30)                              GET00350
0022           30 FORMAT (' ROWS & COLS ')                                     GET00360
0023                READ (IN,35) R1,R2,W1,W2                                   GET00370
0024           35 FORMAT (4I4)                                                 GET00380
0025                IF (IN .EQ. 15) WRITE (15,40)                              GET00390
0026           40 FORMAT (' SIGLEV ')                                          GET00400
0027                READ (IN,120) SIGLEV                                       GET00410
0028                AST = ATT                                                  GET00420
C                                                                              GET00430
0029                IF (IN .EQ. 15) WRITE (15,60)                              GET00440
0030           60 FORMAT (' MIN SIZE ')                                        GET00450
0031                READ (IN,65) MFS                                           GET00460
0032           65 FORMAT (I2)                                                  GET00470
0033                W2 = W2-MOD(R2-R1+1,PXGR+0)                                GET00480
0034                W2 = W2-MOD(W2-W1+1,PXGR+0)                                GET00490
C                   THE USE OF PXGR+0  IN THE ABOVE STATEMENTS AVOIDS          GET00500
C                   AN ERROR FOR ILLEGAL TYPE.                                 GET00510
0035                WIDE = W2-W1+1                                             GET00520
0036                ROWS = R2-R1+1                                             GET00530
0037                PXGRI = PXGR-1                                             GET00540
0038                RL1 = MFS-PXGR1                                            GET00550
0039                IDF = PXGR**2-2                                            GET00560
0040                APGR = PXGR**2                                             GET00570
0041                APGRI = 1.0/APGR                                           GET00580
0042                IF (IN .EQ. 15) WRITE (15,80)                              GET00590
0043           80 FORMAT (' NUMBER OF SPECTRA ')                               GET00600
0044                READ (IN,120) NCHAN                                        GET00610
0045                IF (IN .EQ. 15) WRITE (15,110)                             GET00620
0046           110 FORMAT(' OUTPUT ')                                          GET00630
0047                READ (IN,120) OUT                                          GET00640
0048           120 FORMAT (I1)                                                 GET00650
0049                WRITE (OUT,130) (AFS(I,1),I=1,4)                           GET00660
0050           130 FORMAT (30X4A4)                                             GET00670
0051                DO 300 I = 1,250                                           GET00680
0052           300 STACK(I) = 1                                                GET00690
0053                NEXT = 1                                                   GET00700
0054                PWIDE = WIDE/PXGR                                          GET00710
0055                DO 310 I = 1,130                                           GET00720
0056           310 LASTR(I) = 0                                                GET00730
0057                JLINE = 0                                                  GET00740
0058                IF (IN .EQ. 15) WRITE (15,320)                             GET00750
0059           320 FORMAT (' RUN NUMBER  (I8)')                                GET00760
0060                READ (IN,330) RUNNUM                                       GET00770
0061           330 FORMAT (I8)                                                 GET00780
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0062                CALL GADRUN (RUNNUM,11,IO,ERRGRN)                                  GET00780
0063                IF(ERRGRN.EQ.0) GO TO 335                                          *
0064                WRITE(15,5010) ERRGRN
0065           5010 FORMAT(' GADRUN ERROR ',I2)
0066                PAUSE ' EL BOMBO '
0067           335  CONTINUE                                                          GET00790
0068                DO 340 I = 1,30                                                    GET00800
0069             340 KCSEL(I) = 0
0070                IF (IN .EQ. 15) WRITE (15,350)                                     GET00820
0071             350 FORMAT (' WHICH CHANNELS  (412)')
0072                READ (IN,360)(PIX(I),I=1,NCHAN )                                  GET00840
0073             360 FORMAT (412)
0074                DO 370 I = 1,NCHAN
0075             370 KCSEL(PIX(I)) = 1                                                 GET00850
0076                RETURN                                                             GET00860
0077                END
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FLGS  L.CTR   OBJCODE   ADDR   STMT      SOURCE STATEMENT

                                    1  *        SHIFT IS A FORTRAN CALLED ROUTINE TO CONVERT PIXEL DATA TO      XX 00030
                                    2  *        PROPER INTEGER*2 FORMAT. THE CALLING SEQUENCE IS               XX 00040
                                    3  *        CALL SHIFT (PIX,DATA,WORDS) WHERE PIX IS AN I*2 VECTOR WHERE   XX 00050
                                    4  *        THE CONVERTED DATA IS TO BE PLACED. DATA IS A LOGICAL VECTOR   XX 00060
                                    5  *        WHERE THE DATA COMES IN ONE NUMBER PER BYTE, AND WORDS IS       XX 00070
                                    6  *        THE NUMBER OF NUMBERS TO BE CONVERTED. WORDS IS AN I*2          XX 00080
                                    7  *        VARIABLE.                                                      XX 00090
000000                              8  SHIFT    CSECT                                                          XX 00100
000000  90EC D00C   00000C          9           STM   14,12,12(13)                                             XX 00110
000004  05C0                       10           BALR  12,0                                                     XX 00120
                                   11           USING *,12                                                     XX 00130
000006  5821 0004   00004          12           L     2,4(1)   ADDRESS OF DATA                                XX 00140
00000A  5831 0008   00008          13           L     3,8(1)   ADDRESS OF WORDS                               XX 00150
00000E  5811 0000   00000          14           L     1,0(1)   ADDRESS OF PIX                                 XX 00160
                                   15  *                                                                      XX 00170
000012  1B55                      16           SR    5,5      ZERO BXLE COUNTER                             XX 00180
000014  18AA                      17           SR    10,10    ZERO WORK REGISTER                            XX 00190
000016  5860 C03A   00040          18           L     6,=F'1'  INCREMENT FOR BXLE                            XX 00200
00001A  4873 0000   00000          19           LH    7,0(3)   LOAD WORDS                                    XX 00210
00001E  5870 C03A   00040          20           S     7,=F'1'  GET END OF LOOP CONDITION                      XX 00220
                                   21  *                                                                      XX 00230
000022  43A2 0000   00000          22  LOOP     IC    10,0(2)  LOAD DATA BYTE                                XX 00240
000026  40A1 0000   00000          23           STH   10,0(1)  STORE INTO OUTPUT (PIX)                        XX 00250
00002A  4A20 C03E   00044          24           AH    2,=H'1'  ADD TO DATA ADDRESS                           XX 00260
00002E  4A10 C040   00046          25           AH    1,=H'2' ADD TO STORAGE ADDRESS                         XX 00270
                                   26  *                                                                      XX 00280
000032  8756 C01C   00022          27           BXLE  5,6,LOOP                                               XX 00290
                                   28  *                                                                      XX 00300
000036  982C D01C   0001C          29           LM    2,12,28(13)                                            XX 00310
00003A  92FF D00C   0000C          30           MVI   12(13),X'FF'                                           XX 00320
00003E  07FE                       31           BR    14                                                     XX 00330
                                   32  LTORG    +
000040  00000001                  33  DC  F'1'
000044  0001                      34  DC  H'1'
000046  0002                      35  DC  H'2'
                    00000          36           END   SHIFT                                                    XX 00340
```

Appendix II

Input - Output and Program Variable Information

The CBA program listed in Appendix I operates under the IBM System 360 Model 44 programming system 44PS. The first section of this appendix describes the necessary control information, the second describes the format of the picture data used by the program and the third section describes the program output. The fourth section describes the program variables.

I.

All of the control parameters are read from cards by the subroutine GETPRM. Below is a list of (1) the format of the cards, (2) the program variable into which the data is read, and (3) an explanation of the parameter.

1. 'RUN IDENTIFIER' Format is 4A4. AFS

This defines an alphabetic identifier for the run. This identifier will be printed at the head of the output.

2. 'GROUP SIZE' Format is I1. PXGR

This requests the value of g, the number of pixels on the side of a pixel group. Thus a pixel group has g**2 pixels.

3. 'ROWS & COLS 4I4' Format is 4I4. R1 R2 W1 W2

This requests which rows and columns of the picture are to be processed. Thus it is not necessary to process starting at the top of the picture or at the left of the picture. The data is of the form: first row, last row, first column, last column. If the specified rows and columns are such that they do not come out on a pixel group boundary, the program will delete sufficient rows

and/or columns to come out even. The maximum number of columns which can be processed is 125/(the group size parameter). There is no restriction on the number of rows.

4. 'SIGLEV' Format is I1. SIGLEV

This is the significance level to be used in the t-test. The values of '1', '2', '3', or '4'. A value of '1' will cause the null hypothesis to be rejected most readily and will thus give the least resolution (and cleanest results).

5. 'MIN SIZE' Format is I2. MFS

This requests the number of pixel groups a field must have in order to engage the per field classifier. If you wish to have per field classification performed on all fields, no matter how small, simply punch '01'. Currently this parameter is used only in the dummy per field classifier.

6. 'NUMBER OF CHANNELS' Format is I1. NCHAN

This requests the number of spectral bands to be used in the picture analysis.

7. 'OUTPUT' Format is I1. OUT

This requests the FORTRAN logical data set number to which results are to be written.

8. 'RUN NUMBER' Format I8.

This is the run number of the data set to be processed.

9. 'CHANNELS' Format NI2

Defines the NCHAN channels to be used.

II.

All use of raw digital picture data is in subroutine PGROW. Thus, to use a different format of picture data, only this subroutine must be altered. Subroutine PGROW is called to read in a row of pixel groups. All that PGROW returns are the values of the sums of the pixels in each group (in each channel) and the sums of the squares of the pixels in each group (in each channel). The actual pixel values are not retained. The sum of the elements of the JS'th pixel group in the row for the NS'th channel is placed in ASO(JW,NS). PGROW has available in the named common /INT2/ the number of channel being processed (in NCHAN), the columns of pixels being considered (in W1 and W2) and the size of a side of a pixel group (in PXGR).

III.

The output consists of a heading giving the title, minimum field size, pixel group size, significance level and number of channels process; a printout of column numbers; and the body of results. In the body of results, the row number is printed at the left. This is the pixel row, not the pixel group row so that if each pixel group is 2 pixels on a side, these numbers on the left will be 1, 3, 5 etc. The rest of the body of results consists of field identification characters. Only the boundaries of each field are printed. Field identification is assigned by a dummy per field classifier in subroutine CLASS. As each field is

closed, this dummy per field classifier gives a new identifier to it. After all the available characters have been used, it starts over at the beginning of the list of characters.

IV.

Meaning of FORTRAN Variables in the Closed Field Selection Program

This section gives the meaning of the important FORTRAN variables in the Closed Field Selection Program. All the variables discussed below except ASP are in a COMMON block. The program uses COMMON to pass virtually all information from subroutine to subroutine.

Control information

OUT contains the FORTRAN logical unit number to which results are written.

IN contains the FORTRAN logical unit number from which control information is read.

NCHAN contains the number of channels being processed.

PXGR is the value g in the paper. PXGR1 is PXGR-1.

R1 and R2 are the first and last rows of the picture to be processed.

W1 and W2 are the first and last columns of the picture to be processed.

MFS is the minimum field size. This is used only in the dummy per field classifier.

Field statistics

Each vector of ASUM is the vector s in the report for one channel. Each vector of ASQ is the vector q in the report for one channel. Each vector of AFTOT is the vector S in the report for one channel. Each vector of AFS in the vector Q is the report for one channel.

AFLD(1) contains the number of pixel groups in the field whose statistics are contained in the 1'th row of AFTOT and AFS.

AT(1) is computed only in the statistical subroutine (subroutine STU) and contains the value of t for the 1'th channel.

ASP is a local variable in subroutine STU and is the value of Sp**2.

Utilization of field statistics variables

STACK is a stack vector. It is initialized so that STACK(1) = 1. NEXT says which element of the stack to be used next. Each time a field is started, a number is pulled from the stack and this number is the number of the element of AFLD and row of AFTOT and AFS to be used for this field. Also when a new field is started, NEXT is increased by one. Each time a field is closed, a number is returned to the stack. Thus, if a field is closed which was described by the 10'th element of AFLD and the 10'th row of AFTOT and AFS, the number 10 is put into the stack and the value of NEXT is increased by one.

Indication of current processing

JR contains the number of row currently being processed. JR is pixel row, not pixel group row. JR is the DO index on the overall loop over rows. If PXGR is 2, then JR is incremented by two each

time through the loop.

JW contains the number of the column currently being processed. JW is the DO index on the loop passing through the row from left to right.

RWFLD(1) contains the element number of AFLD containing information concerning the 1'th pixel group in the current row. RWFLD is actually the vector f in the report.

OLDRW is the RWFLD from the previous row. It is actually the vector (f) in the report.

Printing of results

SP is the array of results. SP is dimensioned (130,100) so that each vector of SP is a line of printed result. After a row is processed, SP is loaded from the vector RWFLD. When a field is closed, and the field is classified, all entries in SP referring to that field are altered to reflect the classification. To tell whether a field has been classified, the program puts the classification index +256 into SP for each element of SP representing the field just classified. After 100 lines have been processed, 50 lines of results are printed and then after another 50 lines are processed lines 51-100 are printed and so forth. Anytime the print routine is called, results are printed from the first 50 vectors of SP. Then the second fifty vectors of SP are moved to become the first 50. As processing continues, further results are placed in vectors 51-100.

LASTR is a vector of dimension 130. It is positioned in COMMON immediately before SP and is thus logically the zero'th vector of SP. This is done to preserve the last row of results just printed.

This information is needed by the print routine to know whether a boundary was crossed.

FSR(l) contains the number of the first vector of SP which represents the field described by the l'th element of AFLD. FSR is used after per field classification is done to assist in propagating the field classification index (+256) throughout that part of SP representing the field.

JNR contains the total number of rows of pixel groups processed so far. Each time JNR becomes a multiple of 50 (and is at least 100), 50 lines of results are printed.

JLINE is the counter used to index SP.